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CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER

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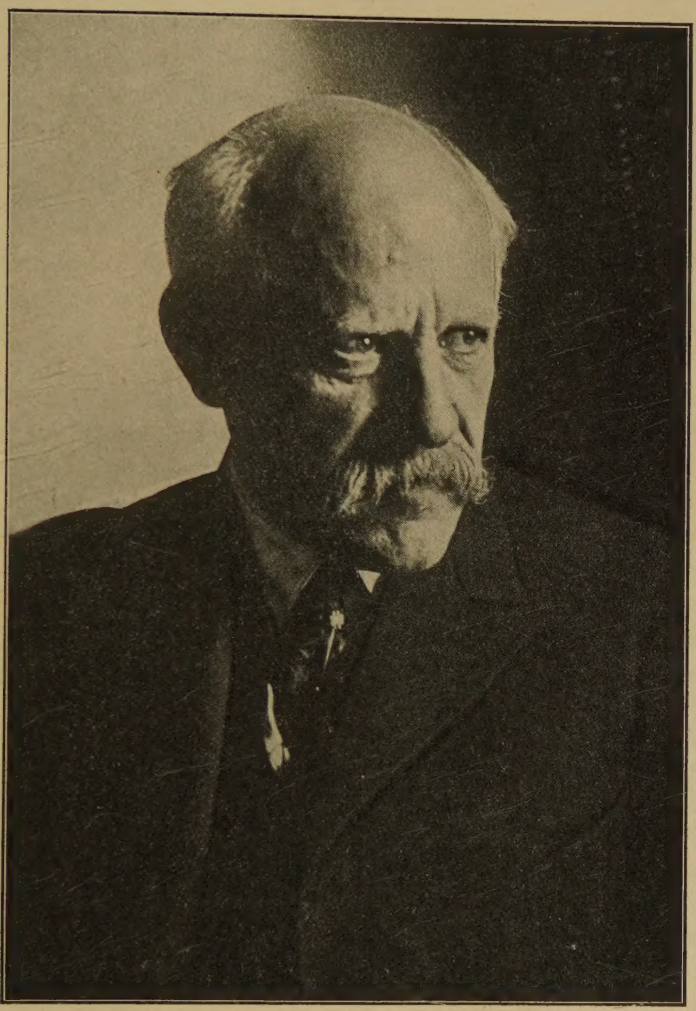

Fridtjof Nansen.
10. October 1861–13. May 1930.

Well-nigh fifty years ago, FRIDTJOF NANSEN had a modest post in the Bergen Museum, then as now a real centre of research and study. It was there I met him for the first time, and I have not forgotten what NANSEN looked like; he was a Norseman of the Sagas, with a Viking's yellow hair, and with strength to wield the hammer of Thor. That was a long time ago, and things have changed marvellously. Among the things which NANSEN took me to see were the leper-hospitals, of which there were three in Bergen alone; I doubt whether there is a single case of leprosy left in Norway today.

Employed in a Natural History Museum, NANSEN's business was the science of zoology; for this he toiled hard and eagerly, and his early papers are not forgotten. One was a monograph of the genus Myzostoma, a little isolated group of parasitic worms, living on the feather-stars and sea-lilies. Another of his early memoirs was on the Hagfish, or *Myxine*, a strange primitive eel-like fish, full of puzzling features both in its habits and its anatomy; NANSEN made the surprising discovery (it was made by Mr. J. T. CUNNINGHAM about the same time) that this ancient fish was, alone among vertebrates, a hermaphrodite animal, male in its youth and female when it grew old.

When I met him first he had already made his first Arctic trip, in the Norwegian sealer "Viking". He set out on the pretext (as he called it) of collecting natural history specimens, but the Greenland ice excited him to new ambitions, and he came home impatient to return. Long years afterwards, in St. Andrews, he said to us: "That was the first fatal step that led me astray from the quiet life of science". A longing awoke in him, and vague plans revolved in his mind, of exploring the unknown interior of Greenland, hidden below the "inland-ice" of its enormous ice-cap. WHYMPER, PEARY and NORDENSKIOLD were among those who had tried, and failed, to cross this vast frozen territory; but the last of these had two Lapps with him, expert ski-runners, and one day a message came to Bergen that these Lapps had found the snow-covered Greenland ice favourable, and had been able to cover long distances on their skis. NANSEN could ski as well as any Lapp, and here he found his opportunity. His plan was to force an entrance on the desolate, ice-bound eastern coast of

Greenland, and force his way through to the settlements on Davis Straits. The "absolute recklessness of the plan" was pointed out by the experts; but NANSEN considered a line of retreat to be "a wretched invention", and the want of it only simplified matters. There would be no need to urge one's men on — for there was no possibility of turning back. The method worked well; NANSEN made his adventurous journey at little cost and in the simplest way; and the book in which he described this "First Crossing of Greenland" was the beginning of his literary fame. The journey only whetted NANSEN's appetite for adventure, and served as an apprenticeship for the great expedition in search of the Pole on which he embarked in the year 1893. He had watched the East Greenland Current flowing south between Greenland and Iceland, bringing not only ice but drift-wood too; and this current, he declared, must have crossed over the Polar Sea from the Siberian side, and had probably come right across the Pole. He planned his course, then, so that he might drift with this current, were it fast or slow; and he built the "Fram" not such as to force her way through the ice but to drift with it, and to be wedged upwards rather than crushed in an ice-jam. His comrades were like the crew of Ulysses, "strong in will, To strive, to seek, to find and not to yield". Some of us remember well, and all of us have heard, how NANSEN disappeared into the Far North and was lost for three years; and how when he reached Spitzbergen at last and came in touch with his fellow men, the whole world acclaimed him with a joyful welcome, as one who was lost and was found. I was in an out-of-the-way part of the world myself just then, on an island in Bering Sea; one day a ship came in bringing us supplies and news, and before ever the ship's boat reached the shore her men shouted to us across the water in their haste to tell us that NANSEN had come home.

NANSEN was now famous, rich, admired of all admirers; but he was too great a man for even flattery to spoil. He was as simple, zealous, hopeful, loveable as before. While he was a born traveller and explorer, he was also, even first and foremost, a scientific man. It was not for mere adventure that he had crossed Greenland, nor that he had sailed farther than any other man had yet done towards the Pole; it was in order to study as well as ever

he could the unknown phenomena of these untrodden regions. If NANSEN began as a zoologist, he soon made himself chemist, physicist, and meteorologist. The instrument we still use for bringing up water-samples from great depths was mainly his invention; the causes of ocean-currents, the surface-tension of liquids, the secular changes in certain coast-lines are among the many physical problems which he became an authority upon. The "Fram" had been none too well equipped, not so much from lack of means as because NANSEN had underestimated the depth of the Polar Sea; but all through the voyage he kept devising rough and ready methods of attacking the great problems at hand, and he spent years afterwards in wresting from his somewhat scanty records the secrets they contained. The fifteen volumes of Scientific Reports of the Norwegian North Polar Expedition (1893—1896), largely written by NANSEN's own hand, form one of the mainstays of our present knowledge of Hydrography and Oceanography. The voyage of the "Fram" did one thing more, and this Dr. H. R. MILL has called "the chief glory of the expedition". It put an end for ever to the old style of polar exploration, where naval officers, with large crews under naval discipline, did their best to carry out the plans and orders of geographers at home. In perilous enterprises, where NANSEN's motto "Forward, Forward" is the only rule, the band of brothers, the crew of Ulysses, is the better way.

Among a host of interesting things which NANSEN's Polar Expedition Reports contain, let me say a word on one. When the "Fram" was making her way along the Siberian coast on her northward voyage she fell in, three times over, with a strange condition of the sea which Norwegian sailormen call "dead water", and of which they were wont to tell stories none too easy to believe. The "Fram" was approaching the ice one day in order to make fast to it; her engines were kept at full speed, but the ship crept along so slowly that NANSEN got into a row-boat to row ahead, and shoot a seal or two. Here was a very strange phenomenon, but it was not a new one. TACITUS speaks of the same thing when he says that in Thule the sea is "tough and hard for the rowers (*pignum et grave remigantibus*)"; and again PLINY gives to a like occurrence the common explanation of his time, when he relates how ANTONY's own galley was mysteriously delayed at Actium,

and how the cause was a little sucking-fish (or *Remora*), which had fastened on its keel. NANSEN was the first to show that this was a real phenomenon, with a definite physical cause; and what that cause was, he and his colleague Dr. WALFRID EKMAN clearly and thoroughly explained. "Dead-water" happens where a surface-layer of fresher or lighter water rests upon the salt water of the sea; as may often happen where a stream runs down into a Norwegian fjord, or where melting ice flows over a calm sea. As NANSEN put it, "the fresh water is carried along with the ship, gliding on the heavier sea beneath as if on a fixed foundation"; moreover, at the surface where the two layers meet, waves are set up just as they are on the open surface of the sea. The fresh water tends to be heaped up ahead of the advancing ship, a sternward pressure opposes her advance, and the friction of water flowing past her keel further impedes her progress. A small ship loses way, refuses to obey her helm, and becomes unmanageable; but a curious thing is that a more powerful ship, going a trifle faster, may ride on the "solitary wave" and be helped rather than impeded.

NANSEN, not long home from his great adventure, was conspicuous at the Conference in Stockholm which, in 1899, prepared the way for our International Council for the Exploration of the Sea; and for several years after the establishment of the Council he was an enthusiastic and most useful member. The scientific side of the Council was very prominent in those days, and, with men like NANSEN, HENSEN, HELLAND-HANSEN, WALFRID EKMAN, CLEVE, KRÜMMEL, BRANDT, HEINCKE and others, it included well-nigh all the best skill and expert knowledge of the time. It was NANSEN's ardent wish that his own country should be recognised as the centre of oceanographical research, and at one time the Council actually resolved to establish its Central Oceanographical Laboratory in Christiania, under NANSEN's charge, with WALFRID EKMAN as his second in command. This project was never carried out; but the present Geophysical Institute in Bergen is precisely such a centre of research as NANSEN dreamed of, strove for, and at last saw realised.

While NANSEN shewed himself an industrious and original investigator all his life long, both in biological and physical science, yet all this neither filled up his time nor used more than a part

of his strength and energy. For well-nigh the latter half of his life NANSEN played a great part in public life and in political affairs. When Norway found it needful to break off her partnership with Sweden, under which King OSCAR held both thrones and wore the double crown, NANSEN was a leader and prime mover of Norwegian opinion; so great was his influence and so deep the people's faith in him that for the time being he was nothing short of their uncrowned King. Then, when the new King was crowned, NANSEN came to England as Norwegian Minister, and held that post just so long and no longer than it seemed to him his duty to do, while the affairs of the new kingdom were settling down. The duties of a diplomat, the etiquette of a courtier, did not trouble him at all; King Edward received him into his intimate friendship, and NANSEN moved as easily in the air of the Foreign Office as in his laboratory at Christiania or on the deck of the "Fram". Without being a courtier he found a welcome in courts; he had a way, somehow, of putting royalty at its ease! In later years, during and after the War, throughout the worst of Russia's troubles or wherever in Germany, Turkey or Armenia there was misery to be succoured and famine to be relieved, NANSEN found his occupation. The Kremlin opened its mysterious doors to him, and LENIN trusted him, like all other men.

It was NANSEN'S good fortune to combine the poet and the dreamer with the man of action and of affairs. Imagination led him on and pure ambition, not thought of fame nor expectation of reward; and the same romantic imagination led him to spend the scanty leisure of years over the Sagas and traditions of his race, and to tell the story, in his curious and beautiful book "In Northern Mists", of the exploration, conquests and discoveries of his Viking forefathers. Some four years ago he came to our University as its Lord Rector, and gave an address to our students on the spirit of "Adventure", a theme that scarce another man had as much right to speak of as he. No orator I have ever heard so moved his hearers as NANSEN moved his student-audience that day. "Oh youth, youth! What a glorious word! Unknown realms ahead of you, hidden behind the mists of the morning..... You are foot-loose and heart-free to sail beyond the sunset, and to roam the universe..... Rooted deep in the nature of every

one of us is the spirit of adventure, the call of the wild, — vibrating under all our actions, making life deeper and higher and nobler.

Let us probe the silent places, let us seek what luck betide us,
Let us journey to a lonely land I know.
There's a whisper on the night-wind, there's a star agleam to guide us,
And the Wild is calling, calling..... let us go."

To describe NANSEN's full and varied life, even to sketch it lightly in these few lines, is to attempt the impossible; but this short story may give us something to think upon. NANSEN was a great figure in the world. Sometimes a world-wide reputation only means that a man is known to all those of his own class or trade; but NANSEN was known to all sorts and conditions of men. What was it that made him great as well as famous? I do not think it was his eloquence or his learning or even his spirit of adventure, nor was it his political ambition nor his statesmanlike insight and skill. It was rather a certain quality of his, a force of character, an air of high distinction which he wore to a degree unmatched in all my experience of men. He came into a room and men gathered round him, he went out into the world and men followed him, he spoke and we all hearkened to him! Moreover his courage never failed, his faith moved mountains out of his way, and his friendship was of the kind which lasts for ever.

D'ARCY W. THOMPSON.

The Problem of Polluted Shellfish, and its Solution.

By

R. W. Dodgson, M. D. (Lond.)
Ministry of Agriculture and Fisheries, Conway, N. Wales.

The problems presented by the sewage pollution of shellfish would not, at first sight, appear to have much in common with those concerned with the "exploration of the sea". As, however, they have for a long time occupied no inconsiderable place in the anxieties and activities of the Fisheries Authorities of the shellfish producing countries, and as their investigation has involved a good deal of biological, physiological, hydrographical, etc. research, a short account may perhaps legitimately be included in this Journal.

The fact that molluscan shellfish, when polluted with sewage, can transmit typhoid fever and other diseases to the human consumer, was definitely established about thirty-five years ago. As a result, public confidence was severely shaken, and ever since that time the industry in England has been under a cloud. Although the prevalence of typhoid fever from all causes has greatly diminished during the period in question, reports of cases attributed to the consumption of polluted shellfish, some of them terminating fatally, are still by no means infrequent; with the result that a large and apparently increasing section of the community continues, and with good reason, to avoid shellfish. Moreover, the general public is becoming educated in the matter of the importance of clean food, and the patent fact that shellfish from unclean beds are eminently a dirty food is exerting a growing adverse influence, apart altogether from the danger of contracting serious specific disease.

At the present time the British shellfish industry is in a crippled condition, certain sections of it being threatened with early extinction — at any rate as far as the home-grown article is concerned. The mussel trade has suffered the most, the taking of mussels for human consumption having been forbidden by the Sanitary Authority in respect of considerably more than half the mussel beds of England and Wales,

and there is every reason to believe that, in consequence of ever increasing pollution and growing vigilance on the part of the authorities, the major part of the remaining beds will share the same fate before long. The oyster industry is, as yet, not so hard hit in the matter of the official condemnation of the fisheries. There has been a serious fall, however, in the number of oysters marketed, and although difficulty in procuring young oysters to re-stock the beds, depleted by the great mortality which occurred about ten years ago, accounts for a proportion of the fall, it is considered by those in closest touch with the wholesale trade that pollution and the fear of pollution are largely responsible.

Numerous attempts to grapple with the situation have been made, but the measures adopted have either been ineffective, or merely palliative, and of insignificant advantage. Removal of the pollution, by deviation of sewers, has not been attempted in this country, owing to prohibitive cost. (In Holland this remedy has been resorted to with success in the case of certain small communities in the Schelde Estuary, where the topographical conditions lend themselves to its successful, and not too costly, application). The various processes for the treatment or so-called purification of sewage offer no solution of the problem, owing to the fact that the treated effluents may be almost if not quite as noxious, from the point of view of their bacterial content, as the crude sewage. Sterilisation of sewage effluents may be achieved by their treatment with chlorine, and such treatment has been successfully applied in a few instances, but the cost of its installation and of its proper supervision is such as to place it entirely out of the question as a safeguard of general application. Relaying the polluted shellfish in unpolluted waters is not practicable. In the case of mussels, suitable relaying grounds can rarely, if ever, be found, at any rate in England and Wales. If they could, the cost of adequate inspection, necessary to ensure that the relaying were properly carried out and that the shellfish if relaid were not re-polluted by storage, prior to marketing, in foul inshore waters, would rule it out. Moreover, the relaid polluted shellfish rapidly foul the relaying grounds, rendering them a potential source of danger. The more valuable oyster will carry higher administrative costs, but, although relaying is carried out in certain cases, not improbably with success, the general objections referred to above negative it as a remedy of wide application.

The result of prolonged observation has been to demonstrate conclusively that we must accept sewage pollution, constantly increasing as it is, as an accomplished and unalterable fact, and that the only solution of the problem lies in the purification of the polluted shellfish,

under conditions which will ensure a product of a constant standard of purity. In this way only can recurring disasters be prevented, public confidence restored, and the shellfish industry rehabilitated. The conditions in question can only be secured by a system of "artificial" purification, in tanks under stringent Government control.

In order that a system of shellfish purification may prove a success: that is to say, provide the solution of the pollution problem: it must satisfy three conditions:—

(1) It must provide a satisfactory safeguard of the public health.
(2) It must be uncomplicated in operation, and capable of standardisation: that is to say, of reduction to a simple routine basis.
(3) The cost of efficient working must not be disproportionate to the market value of the shellfish purified.

The system of mussel purification operated by the Ministry of Agriculture and Fisheries, at Conway, has been shown by experimental evidence, fully confirmed by the results of 14 years' practical operation, completely to satisfy the desiderata set forth in the last paragraph.

It will be convenient first to describe the process as carried out, deferring remarks upon the principles underlying the various stages until later. The general rationale of both mussel and oyster purification is similar. A detailed account of the mussel purification will therefore be given, deviations and modifications necessary in the case of oyster purification following thereon.

Mussel Purification, as carried out at Conway:

The installation consists of four reinforced concrete tanks, as follows:—

No. 1. Storage tank. Capacity: 90,000 gallons (approximately 410,000 litres). Estuarine water is pumped into this tank, at or about high tide, and stored until required. (This is rendered necessary by the fact that enough water of suitable salinity cannot always be obtained on one tide.)

No. 2. Chlorinating tank. Similar in capacity to No. 1, from which it can be filled in about 20 minutes.

Nos. 3 & 4. Mussel purification tanks. Capacity: 40,000 gallons (180,000 litres). These tanks have sloping floors divided into channels by concrete ridges which support wooden grids. By an arrangement of penstocks or sluices the channels under the grids can be effectively flushed out. The average depth of these tanks is 3 feet (approximately 1 metre).

The whole installation is built on sloping land, so that tank No. 2 can be filled from No. 1, and Nos. 3 & 4 from No. 2, by gravity.

Whilst the polluted water from the storage tanks is running into the chlorinating tank, a solution of bleaching powder (calcium hypochlorite) is added to it in quantity sufficient to give a concentration of 3 parts per million of active chlorine. The water is then allowed to stand over one night, when sterilisation is complete.

Steps in the purification process:

I. The polluted mussels are spread, about two deep, on the wooden grids, in tanks 3 & 4.

II. The mussels are thoroughly hosed with a powerful jet of water, which washes adherent mud, weed, etc. from the shells through the grids into the sloping channels, from which all such detritus is flushed by water from the penstock sluices.

III. The tank is filled with sterile sea-water from the chlorinating tanks (No. 2). Whilst the sterile water is entering the tank it receives a dose of sodium thiosulphate sufficient to neutralise any trace of active chlorine which may remain. In this bath of sterile water the mussels remain one night, and into it they discharge all foreign matter, including bacteria, from their intestines, mantle cavities, etc., in the form of fine threads or small pellets, held together by sticky mucus. These threads or pellets fall to the bottom, the bacteria remaining imprisoned in them by the tenacious and practically insoluble mucus.

IV. (After 24 hours.) The first bath is drained off, and the mussels again hosed. This washes the matter discharged by the mussels (fæces, etc.) into the channels under the grids, whence it is flushed, as in "I".

V. The mussels receive their second bath of sterile dechlorinated water, in which they remain another night, and into which they discharge any residual bacteria not removed in the first bath. As in the case of the first bath, the bacteria go to the bottom, held fast in mucus.

VI. (After 48 hours.) The water is again drained off, the mussels hosed, and channels flushed; as in "II".

VII. The mussels are now covered for one hour with sterile water as before, but a solution of calcium hypochlorite is added as it enters the tank, the concentration of active chlorine in the bath being 3 parts per million. This is an actively sterilising bath, its object being to sterilise the outside of the mussel shells, as well

as the grids, tank walls, etc., to which bacteria, which may have been released from the mucoid fæces etc. by the force of the hosing water, may be adhering. (There is no danger of such bacteria being splashed *inside* the shells, as the mussels remain tightly closed during the process of hosing.)

It may here be emphasised that this final bath of one hour's duration is the only occasion during the whole process of purification on which the mussels are exposed to the action of active chlorine.

VIII. (After 1 hour.) The shell-sterilising bath is drained off. The fishermen then enter the tanks, having first sterilised their boots in a solution of 1 in 10,000 active chlorine, and pack the mussels in sacks sterilised the previous day in 1 in 10,000 active chlorine solution. The sacks are sealed with a special safety lead seal bearing the date and the legends "M.A.F." and "Conway", and are despatched to market.

Oyster Purification. Although mussels will function actively in water little if any above freezing point, oysters will not function unless the temperature of the water is above about 6° C. They can generally be relied upon to do so at 8° C., but if vigorous functioning, consistent with rapid and efficient purification, is to be secured, the temperature of the water should not be below 13° C. If, therefore, oyster purification is to be carried on, on anything like a continuous commercial basis during the oyster season (September—April), artificial warming of the water must be resorted to for the major portion of that period.

Again, the flat shape of the oyster renders the removal of mud, etc. from the shells, by hosing, a more difficult task than in the case of mussels, which are turned over and over by the force of the hosing water and thoroughly cleaned. Oysters lying on the flat, especially if there be more than one layer of them, remain more or less in one position, and dirt lodges under the lower shell. It has been found necessary, therefore, to place the oysters on edge. This is achieved by arranging them in racks made of stainless-steel wire.

The Conway oyster purification tanks are much smaller than those used for mussels, their capacity being 2,500 gallons (approximately 11,000 litres); their area being 12 × 12 feet (approximately 4 × 4 metres). There are two tanks only, the upper being the chlorinating tank, the hypochlorite sterilising solution being added as the tank is pumped full from the estuary. (The small quantity of water required can easily be obtained at high tide, in a few minutes. This fact renders a storage tank unnecessary.) Purification is carried out in the lower tank. Both tanks

are enclosed in sheds with double walls and roofs, insulated with a non-heat-conducting packing. The water in the upper or chlorinating tank is warmed to the requisite temperature (say 13° C.) by the circulation of water, warmed in a suitable boiler, through a system of pipes at the bottom of the tank. The warmed sterilised and dechlorinated water is run into the lower purification tank, in which the oysters are arranged on edge in the wire racks. The air in the shed over the chlorinating tank is kept at a temperature of 13° C. by means of a gas radiator, automatically regulated. This device serves to keep the water at the original temperature, loss of heat through the tank walls being negligible owing to the tank being sunk well below the level of the surface of the ground.

The sequence of events in the process of oyster purification is, with slight and unimportant modifications, the same as that followed in the case of mussel purification, described above: that is to say, two changes of sterile water (free from active chlorine); three hosings; and one bath of water containing active chlorine to sterilise the shells.

The expense of oyster purification is considerably greater than that of the treatment of mussels, owing to the higher cost of the covered tanks, etc., and enhanced cost of handling consequent on having to place the oysters by hand in the wire racks. In consideration of the much greater value of oysters, however, the relative cost of purification is not greater than that of mussels. In the case of both oysters and mussels, the cost of purification, in the case of shellfish of reasonably good quality, is so small as to be practically negligible.

It will be seen, from the foregoing brief outline, that the purification of both oysters and mussels depends entirely on the vital activities of the shellfish themselves, in throwing out bacteria and other solid matter. They are subjected to the action of only one bath of water containing active chlorine, the function of which is to sterilise the outside of the shells, and during which the shellfish do not function. Any active chlorine on the shells rapidly becomes inert, owing to the action of the organic matter present, and all possibility of the shellfish having a "chlorine" smell — at any time remote — has disappeared before they reach the market.

Degree of purification achieved. The presence and number of bacteria fermenting lactose, with the production of acid and gas, within 24 hours in the liquid obtained by mincing the body of the shellfish in the shell water, are taken as the criteria of the existence and extent of sewage pollution; 1 c.c. of this fluid being used in routine determinations (an amount approximately equivalent to one-twentieth of a mussel, or one-twelfth of an oyster).

Whatever the extent of the original pollution, the degree of puri-

fication achieved, as demonstrated by many hundreds of analyses, is always of the same order: in other words, shellfish of a standard degree of purity can be relied upon. In a considerable percentage of cases, cultures made from purified shellfish are sterile. There may, however, be a residue of from 1 to 5 lactose-fermenting bacteria per 1 c.c. As an example, the results of 262 consecutive analyses of Conway mussels, made in the course of one season, may be cited. The original unpurified mussels contained from 35 to 5,000 sewage bacteria per 1 c.c., the usual number found being some 200 or 300. The results after purification were as follows:—

90	cultures	were	sterile					
55	—	showed	1	red	colony	in	24	hours
47	—	—	2	-	colonies	in	24	hours
35	—	—	3	-	—	-	24	—
23	—	—	4	-	—	-	24	—
12	—	—	5	-	—	-	24	—

The standard of purity for shellfish treated by the Conway process, which has automatically emerged, is the presence of not more than 5 lactose-fermenting bacteria per 1 c.c. of the shellfish. Prolonged experiment has failed to indicate any method of eliminating the possibility of the occurrence of this small residue of bacteria. For instance, prolongations of the period of purification to a week, with daily changes of water, may make no appreciable difference. That the degree of purity achieved is satisfactory from the public health point of view is indicated by the results of the working of the process at Conway. Thus, before purification was resorted to, reports of typhoid fever and other diseases following the consumption of Conway mussels were received from Sanitary Authorities about once a week, or some 30 or 40 complaints during a season. In the period of 14 years, during which all mussels marketed from Conway have been purified, no complaints have been made. Purified oysters have not yet been placed on the market, but the bacteriological results obtained from oysters treated in the Conway experimental tanks indicate that they should be quite as satisfactory as the mussels.

Space will not permit of a further analysis of the significance of the small residue of bacteria which may persist after purification. It may, however, be stated that the routine test is a particularly stringent one. Not all the red colonies appearing in the culture medium within 24 hours are lactose-fermenters. In the course of the experiments it was shown that glucose derived from glycogen in the shellfish tissues may, and usually does, occur in the cultures. Some of the red-colony-producing

bacteria may, therefore, be — and frequently are — merely glucose fermenters, and consequently not necessarily a criterion of sewage pollution. To make certain, sub-cultures must be made, but as such testing of every colony is impracticable in routine work, each red colony is assumed to be a lactose fermenter. Hence the elimination of bacteria of sewage origin is, as a general rule, more complete than is indicated by the results of routine tests.

Certain chemical, physiological, etc. factors of interest in connection with shellfish purification.

Mechanism by which auto-purification is achieved.

The mechanisms for the elimination of ingested solid material are essentially similar in the mussel and the oyster, being two in number, and their functions being, respectively, the discharge of matter voided from the alimentary canal (fæces), and of surplus matter which has been taken in at the inhalant aperture but which has not been ingested by the mouth. The name "pseudo-fæces" has been applied to the latter as a convenient descriptive term.

In the mussel, the faeces, impelled by the intestinal cilia, are discharged from the anus, and thence pass out through the exhalant siphon. They are in the form of a ribbon, varying, with the size of the mussel, from 0.5 to 2.0 mm. in width, the cross-section being bi-crescentic. These ribbons usually break off, during discharge, into sections of say 0.5 cm. in length, but they may reach a length of 5 cm. or more.

The pseudo-faeces are produced by the action of the recurrent marginal ciliary stream. Within the mantle cavity, along the edge of the mantle where it bounds the inhalant aperture, is a band of cilia which lash in a backward direction. Particles of foreign matter, coming in contact with these cilia, become entangled in mucus, locally produced, and the mass is propelled backward to be extruded as a slender, more or less cylindrical, thread at the point where the two mantle lobes fuse, just posterior to the exhalant siphon. The pseudo-faeces may also take the form of flocculent masses. The recurrent marginal stream is fed from various sources. When there is much suspended matter in the water, the inhalant stream is directed on to the posterior ends of the mantle margins, as a result of the lowering, by muscular action, of the membrane situated in the angle formed by the fusion of the fringed margins of the right and left pallial folds. (It has become customary, during the prosecution of the purification research, to call this fold the "pallial velum".) Here much of the suspended matter, and especially the heavier particles, becoming entangled in mucus, is discharged forthwith as

pseudo-faeces. Material delivered to the labial palps in excess of what can be ingested into the mouth is directed by them on to the anterior end of the mantle-margin, whence it is carried backward and ejected. In whatever position the mussel may be lying, particles dropping into the mantle cavity from the various ciliary food-streams find themselves ultimately in the recurrent marginal stream and are ejected as pseudo-faeces.

As stated above, the production and elimination of faeces and pseudo-faeces in the oyster are essentially similar. In the oyster, however, these dejecta are finally expelled from the mantle cavity by periodical flapping of the shells.

Significance of faeces and pseudo-faeces in connection with purification.

It is important from a practical point of view to differentiate clearly between the appearance of faeces and pseudo-faeces, and experience soon renders the task an easy one. The free passage of faeces is an indication that the mussel is happy and functioning normally. Though generally associated with normal functioning, the passage of pseudo-faeces is not in itself a criterion thereof. A mussel may open its shell in surroundings rendered so uncongenial by the presence of an irritant, such as active chlorine, as to cause it to suspend the passage of faeces and the circulation of water through the mantle cavity. It may, however, pass a considerable quantity of pseudo-faeces. To an observer not well acquainted with the two kinds of discharge, the mussel may appear to be functioning well, and, by inference, undergoing purification. In such circumstances the pseudo-faeces usually appear opalescent and diffuse, and consist almost entirely of mucus. In practice the only conditions under which this phenomenon would be likely to occur, during the first stages of purification, would be where dechlorination of the sterilised water had been omitted. In the final bath for chlorination of the shells, it may sometimes be observed.

The little piles of faeces and pseudo-faeces amongst the mussels, after a night in the purification bath, afford a good criterion of the functioning that has been going on. Their absence would show that something was wrong: e.g., the use of water of too low salinity, etc. The organisation of the purification routine is such, however, that accidents of the nature of those just instanced are all but ruled out in practice.

The mucus forming the matrix of faeces and pseudo-faeces is very tenacious, and is not only apparently insoluble in sea-water but shows no tendency to become emulsified or diffused therein. Faeces have been kept in still sea-water for a period of over six months without showing

any signs of alteration. They will resist very considerable water disturbance, e. g. swirling round in a beaker, without showing signs of disintegration, further than breaking up into shorter lengths. The more flucculent pseudo-faeces are less resistent. Sewage bacteria entangled or fixed in the mucus of faeces and pseudo-faeces show little or no tendency to escape. Repeated experiment has shown that the water in the immediate vicinity of masses of these dejecta heavily charged with such bacteria may remain sterile for 48 hours at least (the duration of the experiments). This phenomenon is not dependent on the death of the imprisoned bacteria, for though they die out fairly rapidly when free in sea-water, they have been shown to remain alive in quantity in faeces for as long as seven days. (It may be added here that sewage bacteria may survive in the bodies of shellfish stored out of water for seven days, in almost undiminished numbers, whilst a significant number may persist after 15 days or more.)

Though the dejecta offer such marked resistence to disintegration, it is desirable to avoid water disturbance as much as possible during purification. For this reason the depth of water in the mussel purification tanks is such (minimum 2 feet 9 inches = 0.85 metre) as practically to eliminate the gross effects of wind disturbance at the bottom. In the case of the enclosed oyster purification tanks, this consideration does not arise, and much shallower water can be used. Disintegration of faeces and especially of pseudo-faeces is, of course, caused by hosing. Hence the importance of the final chlorine bath to sterilise the shells. A similar shell-sterilising bath at the termination of the hosing on the first day would clearly be of advantage, but it is omitted as it has been noted that a certain proportion of mussels so treated may fail to function properly for 24 hours after exposure to water containing active chlorine of the necessary concentration.

Circulation of water through the mantle cavity of the mussel.

The volume of water, impelled by the gill cilia, passing through the mantle cavity is surprisingly large. Observation of the time required for mussels to filter all the suspended matter from a given volume of water show that it amounts to at least 10 gallons (45.4 litres) in 24 hours. (That the volume may actually be of the order of 40 gallons, or 170 litres, is indicated by certain observations now in progress.) The clearing of the water during the purification period is a somewhat striking phenomenon. The sterilised water, when the purification tank is filled, is often highly turbid. Within $1^1/_2$ to 2 hours, however, the whole of the suspended matter has been filtered out by the mussels, the water being

of remarkable clarity; the bulk of the solid matter having been thrown out by the mussels in the form of pseudo-faeces, whilst some of that ingested by mouth has already been passed out as faeces. This clearing of the water is always carefully noted, as it affords a reliable criterion of the efficiency of the functioning of the mussels. (The number of mussels in a tank is of the order of 150,000, and the volume of water is approximately 36,000 gallons or 160,000 litres.) It has been shown that ciliary activity in the mussel varies markedly with the temperature, yet the time occupied in the clearing of the water in the tanks remains almost constant over the ordinary winter range of temperatures. Indeed, it has been noted that the clearing may be definitely slower in the spring, at temperatures as high as 10° C., than during the winter at temperatures as low as 1.5° C. No explanation of these apparently contradictory facts is forthcoming.

The water entering by the inhalant aperture passes between the gill filaments into the supra-branchial chamber and out by the exhalant siphon. During its passage through the gills (which are predominantly accessory feeding, rather than respiratory, organs), suspended matter is intercepted and, entangled in gill-mucus, is carried by ciliary streams to the mouth, by which part of it is ingested, the residue being rejected via the recurrent marginal stream, as described above. The gill filtration, partly mechanical and partly mucoid, is so efficient that all suspended particles down to the size of those found in a colloid clay suspension are intercepted, and the majority of bacteria are also filtered out. On occasion the water issuing from the siphons of mussels immersed in highly polluted water has been found to be sterile in volumes of 5 c.c.

The efficiency of filtration is reflected in the fact, proved by numerous experiments, that the standard degree of purification (i.e. not more than 5 bacteria per 1 c.c. of mussel substance) may be achieved equally well if the mussels be immersed in two consecutive baths of highly polluted water instead of sterilised water. The use of sterilised water is, in fact, merely in the nature of an added precaution, taken to ensure that the small residue of bacteria found in purified mussels shall not contain any of the bacteria in the polluted water from the storage tank which might, of course, include typhoid or other noxious microbes.

Experiments with polluted mussels placed in a stream of running sea-water, of sufficient force to carry away all faeces and pseudo-faeces as they are extruded, show that complete purification may be achieved within 20 hours (in some cases 9 or 10 hours sufficed) The bulk of the bacteria disappear during the first half hour (e.g. a reduction from an average of 260 to 30 per c.c.) whilst the residue after 2 or 3 hours is very

small (in the experiment cited it averaged 5 per c.c. after $2^1/_2$ hours). Feeding experiments have shown that a mussel may discharge the contents of the whole length of the alimentary tract in $1^1/_2$ hours, a point of interest in view of the very significant drop in the bacterial content of the mussel after 2 or 3 hours.

Unfortunately it is quite impracticable to treat mussels on a commercial scale in running sterilised sea-water. That a certain amount of re-infection may occur when the mussels are treated in stagnant water would seem to be indicated by the results observed after the first purification bath. After this bath the degree of purification may reach the standard (not more than 5 bacteria per 1 c.c.), but a residue as high as 30 or more per 1 c.c. may be found. As stated above, the degree of purification after the second bath is constant, within narrow limits, and a series of further baths may not alter the result.

Suspended matter in the water in relation to purification.

As shown above, the whole of the suspended matter in the water of the purification bath is thrown down in faeces and pseudo-faeces, the bulk of it being in the latter form. The production of pseudo-faeces, in quantity, connotes copious secretion of mucus along the recurrent marginal tract. The greater the quantity of mucus the more efficiently will bacteria be trapped and fixed. Hence, the more turbid the water, the more efficient the purification. The amount of active chlorine used (3 parts per million) has been found to be effective with the most turbid estuarine waters encountered. Hence, as far as sterilisation is concerned, there is no object in pre-filtration (e.g., through sand), and such filtration would be of definite disadvantage to purification. (Three parts per million of active chlorine provides a very large factor of safety, under ordinary conditions. The amount is calculated to meet all exceptional conditions likely to arise. The two adverse factors to be guarded against are rapid discharge of the active chlorine by the action of excessive sunlight or by excess of organic matter in the water; the former being significant only if the water is clear, whilst the latter is usually associated with excess of suspended matter.)

Purification of shellfish by the direct action of sterilising agents.

Prolonged experimentation has failed to reveal any chemical sterilising agent which can be used with success for shellfish purification. Active chlorine, in the forms of calcium hypochlorite, electrolytic sodium hypochlorite, and chlorine gas, have such a powerful inhibitory effect on the functioning of shellfish that their use is ruled out. Mussels, for instance,

will not function in concentrations higher than about 0.5 parts of active chlorine per million, and it is doubtful whether they will function normally in concentrations over 0.25 parts per million. Whether they can be relied upon to function at this concentration: that is to say, at about the limit of concentration demonstrable by the KI-Sodium thiosulphate test: is a moot point.

Mussels may open their shells (as widely as 1 cm. perhaps) and remain open in concentrations of active chlorine as high as 3 parts per million, and in concentrations of say from 0.5 to 1 part per million they usually do so, but functioning is in abeyance. The circulation of water through the mantle cavity is entirely suspended owing to closure of the exhalant aperture, either by a sphincter-like closure of the outer margin of the siphon, or by the approximation of the edges of the two musculomembranous septa at the base of the siphon, or by both. The passage of faeces ceases. This is not merely an apparent stoppage, due to the closure of the siphon, but an actual cessation of passage *per anum*. The tentacles usually remain closely interlocked. The only evidence of functioning is provided by the passage of mucoid pseudo-faeces, sometimes in quantity.

There are certain limiting concentrations, between about 0.5 and 0.2 parts per million, in which mussels may function after a fashion, but they show numerous signs of annoyance (e.g. irregular opening and closing of exhalant siphons, etc. etc.). Though most of the mussels function normally after the complete discharge of the active chlorine, there are almost always some of them which close up and remain closed for 24 hours or so: a fact in itself sufficient to negative the use of active chlorine for purification purposes.

Bacteriological tests show that mussels immersed in concentrations strong enough to inhibit functioning, as described above, undergo no purification. The results from concentrations weak enough to allow of modified functioning are always worse than those from controls in which no active chlorine is used, and even the use of minimal doses of chlorine (say 0.2 parts per million) has never shown results better than those obtained in chlorine-free water. In any case, the practical difficulties in working with such minute doses of a fugitive substance like active chlorine are insurmountable, at any rate on a commercial scale. At the best, little if any good could accrue, and the danger of overdosage in connection with the necessary addition of fresh chlorine, to keep up the strength, would be very difficult to guard against. In short, the use of minimal doses of chlorine would constitute a menace rather than a help.

An attempt to achieve purification of oysters by the direct action of chlorine, in the form of one of the more stable chloramine compounds,

was made: "Halazone" (p. sulphon-dichloramino-benzoic acid), already used with success in the sterilization of drinking-water, being employed. Although the oysters appeared to function normally in a concentration of 0.6 parts per million of Halazone chlorine, and although the strength of the solution was well maintained, the bacteriological results were no better than those obtained with sterilised water alone.

Temperature in relation to purification.

The necessity for maintaining a temperature over about 8° C., and preferably about 13.5° C., throughout the stages of oyster purification has already been referred to.

Mussels are much more tolerant of low temperatures than oysters. They may be frozen almost solid: that is to say, gills and mantle hard and friable, and shell-water frozen: and yet be functioning normally again within 12 hours or so, provided the freezing and thawing are not too rapid.

Mussels will function actively and undergo satisfactory purification in water at 0° C. A peculiar fact associated with functioning at such low temperatures is that the mussels remain closed, as a rule, during daylight. They may lie closed all day, the turbidity of the tank water showing no diminution, but begin to function vigorously, apparently with one accord, at dusk, filtering the suspended matter out of the water in a couple of hours or so. (This clearing of the water can be readily observed with an ordinary flash lamp.) This peculiar night functioning has been observed, on many occasions, over a water temperature range of 0°—2.5° C. (On rare occasions, mussels may fail to function until darkness sets in, even when the temperature of the water is quite high: e.g. 7° C.)

Although bacteriological analyses demonstrated that the usual standard of purification was repeatedly reached when the temperature of the tank water, throughout the operations, had not exceeded 1° C., it was considered desirable to allow a reasonable factor of safety. The rule was therefore made that mussels should not be released for market until they had been for at least one night in water the bottom temperature of which had not fallen below 4° C., and this rule is still adhered to at Conway. If necessary, the mussels are kept in the tanks, with a daily change of sterilised water, for four complete days. If the water temperature still keeps too low the mussels are returned to the beds.

Fishing for mussels is discontinued during actual frost. Mussels brought to the tanks for treatment the next day are kept in a special frost-proof shed. No hosing of mussels is allowed when the temperature is below freezing point, as efficient washing would be impossible owing to mud, faeces, etc. freezing on to the shells and grids.

Mussels function normally through a wide range of temperatures. They have been observed functioning exceptionally vigorously in water at 26° C. A working rule has nevertheless been made at Conway that purification operations shall be suspended if the temperature of the tank water exceeds 18° C. or if the air temperature at the time the hosing operations should be carried out exceeds 21° C. This rule was made in consequence of heavy mortalities amongst the mussels under purification, which occurred at the beginning of two mussel seasons (in early September). The only special condition noted as being common to the two occasions was a sudden access of very hot weather. The correlation between the high temperature and the mortality is not proven, but it is noteworthy that at the beginning of the remaining twelve seasons unaccompanied by excessive temperatures, no unusual mortality has been observed.

Salinity of water required for purification.

Experiment has shown that mussels — even those taken from situations where they have become habituated to a salinity of about 34.5 (g. per kilo) — will always function normally in water of a salinity of 19, and as a general rule in water of a salinity of 16. (They can be gradually educated to tolerate much lower salinities, but this fact is not of interest in connection with purification.) As a factor of safety is desirable, the rule has been made that the minimum salinity of water used for purification shall be 21.5. It has been found that, for practical purposes, hydrometer readings are sufficiently accurate for routine work, the variations due to alterations in temperature not being significant in this particular connection. The various salinities in question have been translated into the equivalent specific gravities at 13° C. In practice, therefore, the criterion of the minimum salinity of water suitable for purification purposes is a specific gravity of 1016 (equivalent to a salinity of 21.5 at 13° C.). As the temperature of the water is always recorded, the specific gravities can be translated into salinities, but in practice this is found to be unnecessary.

Relation of the quantity and quality of shellfish pollution in their relation to purification.

Experience has shown that the quantity of sewage pollution in shellfish: that is to say, the number of bacteria of sewage origin found in them: has no observable effect upon the results achieved by the purification process. It is immaterial whether the number be excessive: for instance, 1,000 per 1 c.c. (say 25,000 per mussel): or relatively small — for instance, 20 per 1 c.c. (say 500 per mussel). In either case, the

end result is the same, namely, either sterility or a small residue of not more than 5 bacteria per 1 c.c. Hence standard purification is achieved, whatever the source of the mussels.

In view of the possible small residue of sewage bacteria in purified shellfish, we have to take the quality of the pollution into consideration. Crude sewage contains undisintegrated faecal masses, and such masses are to be found in the water in the immediate vicinity of the sewer outfalls and for some considerable distance around them. In the sea and in tidal waters disintegration is, however, rapid, and the farther we recede from the outfalls the greater is the approximation to an even distribution of free sewage bacteria in the water. It follows, therefore, that the farther the shellfish beds are from the sewer outfall the greater is the likelihood of the shellfish containing a fair average sample of the sewage bacteria: or, put in another way, the greater will be the probability of any typhoid bacilli issuing from the sewer mouth being evenly distributed amongst the shellfish — that is to say, of each shellfish having the minimal dose of typhoid infection.

In the vicinity of the sewer mouth, however, typhoid bacilli, present in the sewage, may be anything but evenly distributed. They may be still imprisoned in undisintegrated faeces, or, if liberated therefrom, they may be much more numerous in one part of the, as yet, unhomogeneous suspension than in another.

Hence, mussels feeding near an outfall may ingest undisintegrated particles of typhoid faeces, or, short of that, a massive dose of free typhoid bacilli.

As a small residue (5 or less per 1 c.c.) of sewage bacteria is liable to be found in purified mussels, it is imperative to take the above facts into consideration. It appears probable, for the reasons just cited, that the residue of bacteria which may be found in individual mussels after purification is more liable to contain harmful constituents if the mussels be taken near a sewer, rather than further afield.

Acting on this hypothesis, a rule was made prohibiting the taking of mussels in the immediate vicinity of the Conway sewers. In determining the extent of the prohibited area, the force and direction of the local tidal currents and eddies were taken into consideration. The line of demarcation is about a quarter of a mile (0.15 kilometer) away.

The question of the quality of the pollution hardly arises in the case of oysters, as oyster beds and layings do not, as a rule, occur in the immediate vicinity of sewers.

Several other points of essential importance in connection with the practical conduct of the purification process have emerged from ex-

perimental work on the physiology of the mussel and oyster, and the bacteriology of pollution, — for instance the effects of rough handling, interference with the byssus, etc. — but the preceding brief account will perhaps suffice for the purpose of conveying a general idea. As is almost inevitable in the case of investigations involving the living organism, we find ourselves confronted with not a few apparent inconsistencies and contradictions (indications of some of which will be found in the preceding account). The point of chief importance, from the point of view of the shellfish industry, is that the purification process, largely empirical as it is, has stood the test of time, and affords, it is believed, a satisfactory solution of the vexed problem of shellfish pollution.

The Conway mussel fishery, closed on sanitary grounds in 1913, was resuscitated with the help of purification in 1916, and has been in a prosperous condition ever since. It provides a livelihood for about forty fishermen and their families. The output of the purification tanks is about 10,000 bags of mussels per annum. A bag weighs about 140 pounds (approximately 63.5 kilograms). The price received by the fishermen is from 8 to 10 shillings per bag, from which must be deducted the fee of 1.5 shillings for the purification of the mussels. (1 shilling is equivalent to 6 francs, 1 mark, 0.9 kroner, or 0.6 florins).

Summary.

1. The mollusc-shellfish industry in England is seriously prejudiced by the existence of sewage pollution.

2. Measures for the elimination of sewage-pollution being impracticable, the only solution of the problem lies in purification of the shellfish under Government control.

3. Systems of purification of mussels and oysters have been established by the Ministry of Agriculture and Fisheries; mussel purification having been in operation at Conway, with complete success from both the fishery and the public health points of view, for the last 14 years.

4. Purification is effected solely by the physiological functioning of the shellfish themselves in sterilised water. The shellfish are not exposed to any chemical disinfection until purification is completed, when they are immersed for one hour in water containing 3 parts per million of active chlorine (calcium hypochlorite) for the purpose of sterilising the outside of the shells only. The purified shellfish are sent to market in sterilised bags bearing the seal of the Ministry of Agriculture and Fisheries.

5. The rationale of purification depends upon the immobilisation or fixing of the sewage bacteria in the mucoid discharges of the shellfish, which sink to the bottom of the tanks and are washed away through the grids upon which the shellfish lie by hosing with high presure water. The shellfish circulate the whole of the water in the tanks many times through their gills during the purification period, filtering out and immobilising any bacteria originally free in the water. For this reason sterilisation of the water used for purification is not essential, but is practised as an added precaution.

6. The tank installations and purification operations followed in the case of oysters and mussels are described.

7. A standard of purity for purified shellfish has been automatically established, namely not more than 5 lactose-fermenting bacteria per 1 c.c. of shellfish substance (say 60 per oyster or 100 per mussel of average size).

8. Certain factors of importance in connection with purification are dealt with, namely temperature, salinity of the water, and the quality (as distinct from quantity) of the pollution.

9. The impracticability of purification of shellfish (except the outside of the shells) by the direct action of chemical disinfectants is emphasised.

References.

The whole question of shellfish pollution, with special reference to the purification of mussels, is fully dealt with in the following publication, which contains an extensive bibliography.

Ministry of Agriculture & Fisheries. Fishery Investigations, Series II., Vol. X., No. 1. 1928.
"Report on Mussel Purification", by R. W. Dodgson.
Published by His Majesty's Stationery Office, Adastral House, Kingsway, London, W. C. 2.

Information with regard to the system of oyster purification referred to in this paper will be found in the:

"Report on Sea Fisheries for the years 1920—1923" of the Ministry of Agriculture & Fisheries; and in the Annual Reports on Sea Fisheries for the years 1924—1928.
Published by H. M. Stationery Office, as above.

The Water Movements in the Straits of Dover.

Exceptional Currents in Winter 1929–30.

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It is the chief purpose of this paper to set down and to discuss briefly, a pair of unusually interesting records obtained in the course of the English current measurements now always in train from the Varne Lightvessel (50°56′ N. 1°17′ E.). From this wooden lightvessel, situated so conveniently in the middle of the Straits of Dover, observations by means of a Drift Indicator have been continuously made for several years, and have enabled us to collect an unbroken series of records yielding direct information upon the flow of water through this important link between North Sea and English Channel.

The records amassed in the course of the investigations date back to June 1926, and those obtained up to January 1928 have been published (**1**)[1]).

By the end of 1929, it was possible to look back upon some 1170 days of actual observation. Since it is here intended to deal with two records of a very exceptional nature, it is obviously essential to convey first an adequate idea of the most usual state of affairs. The normal regimen can perhaps best be indicated by referring to the results which have been obtained by massing all the records falling within a three year period containing and ending with May 1929. This three year period embraces 969 observation days, during which time about 19,200 "miles of passing water" were measured. It was found (and this is the result to which particular attention is directed here) that all the varying to and fro water movements in the Straits of Dover during the three year period, effected the same overall transport of water as would have been brought about if a persistent current of 2.7 miles a day from Channel

[1]) Bold figures in brackets refer to the brief list of papers cited; this list is to be found at the end of the paper.

to North Sea had prevailed unchanged throughout the entire period of 969 days.

An imaginary 3 day record has been prepared from the imaginary 969 day record which resulted from this massing of all the individual records falling within the three year period referred to — this by simple proportion. It occurs below as Figure 3 and serves admirably to depict the most usual state of affairs, and to throw into sharp relief the very unusual pair of actual records with which we are concerned (see Figs. 1 and 2 below).

It is possible, broadly speaking, to say that during nine months of the year (February to October) the residual current expressed as a monthly mean, fluctuates with no great variations around the figure in question, namely:—

2.7 miles a day towards the North Sea.

This statement would be seen to be permissible if one could give here the appropriate mean values worked out for four Junes, four Julys and so on. Now, during the other three months of the year (November, December, and January) have occurred the most pronounced departures from the grand mean just set down. These departures are sufficiently marked as to stand out prominently even when we consider for each of the three months named, mean values based upon observations carried out continuously during several Novembers, several Decembers and several Januarys.

The following few figures will have to suffice here to illustrate certain features to which we wish to draw attention.

For the pairs, trios, and quartets of Novembers, Decembers, and Januarys mentioned below, the mean residual current is given in sea miles per lunar day towards a true direction.

Novembers of 1926—27	4.68	N. 57° E.
Decembers of 1926—27	0.30	S. 12° E.
Januarys of 1927—28	5.81	N. 48° E.
Novembers of 1926—28	4.67	N. 45° E.
Decembers of 1926—28	0.60	N. 4° E.
Januarys of 1927—29	4.10	N. 44° E.
Novembers of 1926—29	5.30	N. 45° E.
Decembers of 1926—29	3.00	N. 43° E.
Januarys of 1927—30	5.00	N. 45° E.

Two main facts emerge from a study of these figures. Firstly we see that, judged by the grand mean given above, it is usual in November and January to observe especially strong residual currents from Channel to North Sea, and secondly, that the contrary is apparently the case in December. The figures set down for December reflect the fact that it is in this month that the most pronounced reversals of the usual flow of water from Channel to North Sea have taken place since the investigations began. This comment holds for the three years 1926—28 but what of 1929!?

Commonly, although reversals have been more frequent in December than in other months, there are many individual December records of strong E.N.E. going flow, but these have been, when the whole month is considered, almost completely counterbalanced by the reversals. The result is that December viewed as a whole month, has appeared on the basis of the first three years' records, to be a month of almost nil flow.

It follows from the figures presented, that December 1929 was very exceptional. Detailed figures could easily be quoted to show how emphatically this was the case, but when it is stated that the mean daily flow during the whole month was 11.4 miles a day towards the North Sea, little further comment remains necessary on this score. It may also be stated that during the whole of the two months November 1929 and January 1930, the residual current was in its most usual (E.N.E. going) direction and stronger than during the previous Novembers and Januarys falling within the observational period.

Hence one may remark that, during the three months November 1929, December 1929, and January 1930, there was an unusually persistent and exceptionally strong flow of water from English Channel to North Sea. This fact results in large measure as we have seen, from an almost complete absence of those reversals of the current which have in previous years characterised December, and, to a less extent January. Expressed in a way which can readily be appreciated, one can state that:—

During the three months centred on December 1929, the transport of water from English Channel to North Sea was almost $2^1/_2$ times as great as during any of the three previous corresponding periods.

It will remain to be seen what helpful application if any, can be made of this information to cognate fishery research problems. We have particularly in mind here of course, the question of the dispersal of the eggs and larvæ produced by the great plaice spawning in the Southern Bight. From what has been said, it will readily be realised that one

could hardly imagine current conditions more favourable to secure the transport of the entire products of the plaice spawning to those nursery grounds whose attainment is held to be so vital — than prevailed so unmistakably during the most recent spawning period. Whether the most recent plaice brood will give rise to a particularly rich population of adults after the lapse of the requisite number of years, is a matter duly noted down for attention when the time arrives.

In the publication already cited (1) it was shown how closely the water exchange between North Sea and English Channel marches with the varying distributions of wind prevailing over these two sea areas. Several actual observations are given in the publication mentioned, and relevant meteorological charts are there reproduced to enable a parallel study of current meter records and wind systems to be made.

If the whole bosom of the North Sea be swept by southerly winds whilst the English Channel is, over its whole extent, under the influence of south-westerly winds, then the conditions for maximum E.N.E. going flow through the Straits of Dover are best developed.

Consider an occasion when the winds over both areas are just opposite in sense and you have the best conditions for a W.S.W. going residual current, i.e. for a reversal of the most usual flow.

These distributions of wind over North Sea and English Channel, are best and most potently developed as a result of the existence of extra steep "Lows" and "Highs" which persist for some days centred over certain parts of the British Isles. Thus a steep persistent "Low" centred over the Faroes can give ideal wind conditions for the promotion of an unusually strong E.N.E. going flow through Dover Straits, whilst a well developed "High" similarly situated can yield just those wind conditions most potent in bringing about a reversal (see below Charts III and IV).

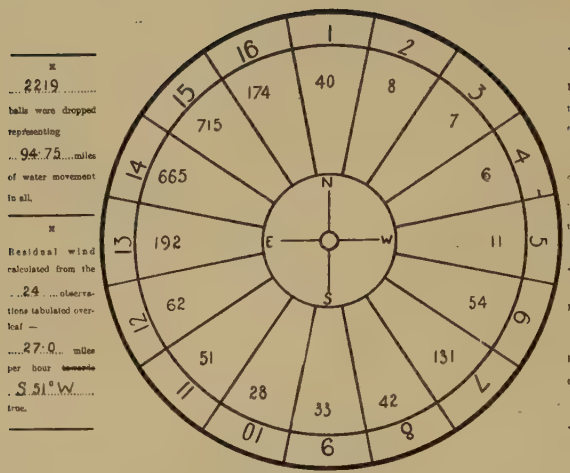
Now during recent months (November 1929 to January 1930) we have had boisterous weather giving long periods of strong persistent winds of the "pro E.N.E. going flow" type. The almost complete absence during these months of winds which condition a current reversal was remarkable, but with February 1930 came a change — particularly with the days following Tuesday, February 5th. During the second week of January 1930, the "pro E.N.E. going flow" wind conditions became so well developed, that a flow from Channel to North Sea of unprecedented amount was registered. The abrupt change over in February to "pro reversal" wind conditions was very interesting (and, for the Writer's investigations, very satisfactory) indeed. There arose such a fine development of northerly and north easterly winds over

the North Sea and English Channel, that a W.S.W. going flow of record strength occurred.

The gale of January 12th, 1930, which occurred during the observation yielding the unprecedented E.N.E. going flow, is the subject of a special article in the Meteorological Magazine of February 1930. The abrupt change over from one to the other of the significant wind distribution types is dealt with in an article in the same publication[1]). We there read of the abrupt change from the weather of December and January to that of February with its persistent north easterly winds over England. The change in pressure distribution was very marked; "in December and January, pressure was more than 15 mb below normal between Iceland and the Faroes; in February pressure was more than 10 mb. above normal over the Faroes and Shetlands."

These abrupt pressure distribution changes gave us that change in wind distribution over North Sea and English Channel which was reflected in the hardly less abrupt change over from unusually strong E.N.E. going to unusually strong W.S.W. going currents through Dover Straits. Below (as Figs. 1 and 2) are reproduced the essential parts of the relevant current meter record forms. A few explanatory remarks are necessary to render these intelligible. The instrument with which the observations were made, has been fully described in print (**1** and **2**) but in view of certain minor but important improvements made to it since the accounts of it were issued, a few notes on, and one or two illustrations of, the Drift Indicator in its definitive form as now in use — are appended to this present paper. It will suffice to recall here, that the instrument comprises essentially a stream lined body containing a mechanism which operates to drop phosphor bronze balls from time to time from a large hopper and allows them to fall upon the runway carried on the north seeking end of a compass system. This is effected as the result of a train of gear wheels being turned by a set of cups driven by the moving water, when the instrument, suspended in the sea, takes up the direction of the stream. In effect, the instrument may be regarded as a special adaptation of the well known Ekman current meter designed to work for long periods under very rough conditions. To facilitate the recording of the results of the observations (which usually last three days) the observers are provided with a record sheet bearing what is to all intents and purposes, a picture of the radially divided box which receives the dropped balls. On such a sheet, the receiving box is seen

[1]) By Dr. C. E. P. Brooks and entitled "The Weather of the Past Winter — Some Comparisons". See Met. Mag. March 1930. See also an article by R. Corless in Q. J. Roy. Met. Soc. April 1930. p. 184.



2219 balls were dropped representing 94·75 miles of water movement in all.

Residual wind calculated from the 24 observations tabulated overleaf — 27·0 miles per hour towards S 51° W true.

Resultant water movement during the entire period of 3 lunar days :— 63·07 miles towards N 50° E true

Residual Current :— 21·0 miles per Lunar Day towards :— N 50° E true

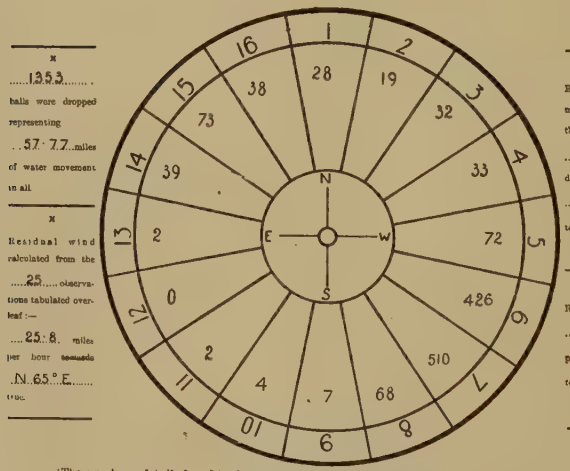
(The numbers of balls found in the various compartments of the Instrument are to be entered in the corresponding places in the above figure.)

	DATE.	HOUR.
Time of commencement of the observations	10 · 1 · 30	11·15 am.
Time of cessation of the observations	13 · 1 · 30	1·45 pm.
Duration of the observations	74 hours.	30 mins.

State of the Tides (*i.e.* "Springs," "Neaps") :— SPRINGS MAKING

State of the Moon (give date of nearest Full or New) :— FULL 14th.

Fig. 1. The Drift Indicator Record which sets forth the strongest flow of water past the VarneLightvessel in the customary ENE going direction — yet measured.



1353 balls were dropped representing 57·77 miles of water movement in all.

Residual wind calculated from the 25 observations tabulated overleaf :— 25·8 miles per hour towards N 65° E true.

Resultant water movement during the entire period of 3 lunar days :— 38·89 miles towards S 51° W true.

Residual Current :— 12·9 miles per Lunar Day towards :— S 51° W true

(The numbers of balls found in the various compartments of the Instrument are to be entered in the corresponding places in the above figure.)

	DATE.	HOUR.
Time of commencement of the observations	7 · 2 · 30	6·45 pm
Time of cessation of the observations	10 · 2 · 30	9·15 pm
Duration of the observations	74 hours.	30 mins.

State of the Tides (*i.e.* "Springs," "Neaps") :— NEAPS PASSING.

State of the Moon (give date of nearest Full or New) :— FULL ON 13th.

Fig. 2. The Drift Indicator Record which sets forth the most pronounced reversal of the customary ENE going flow past the Varne Lightvessel — yet measured.

Fig. 3. The Representative Three Day Record.
[Obtained by reducing to a three day basis that imaginary 969 day record which resulted from massing all the records collected during three years of observations at the Varne Lightvessel].

in horizontal section, and the numbers entered in the various numbered direction sectors, signify that those numbers of balls were counted out from the corresponding compartments of the instrument after the conclusion of an observation. The mileage equivalent of the number of balls dropped in the course of an observation, can be regarded as giving a direct measure of the briskness of the tidal streams at the time. Such a value therefore is here entered upon the reproduced record forms relating to the two unprecedented records, and, for purposes of comparison, the same information is given on the imaginary three day record depicting the most usual state of affairs.

Before commenting on the foregoing pair of very interesting records with the object of displaying their marked departures from that usual state of affairs depicted by the representative record (Fig. 3), attention is directed to the following charts (Charts III and IV) and to further relevant wind data. The two composite charts (Charts I and II) were prepared with great convenience by simply mounting side by side the appropriate weather chartlets from the daily weather columns of the Times newspaper. Being of a small size and already in black and white, these have served ideally for reproduction here to span the whole of the two observation periods. It has, however, been thought desirable to give also two very appropriate synoptic meteorological charts issued by the

British Meteorological Service. These two individual official charts (Charts III and IV) have been chosen to show more clearly ideal developments of wind distribution respectively favouring E.N.E. going flow through Dover Straits and pronounced reversal of the same, and this they do

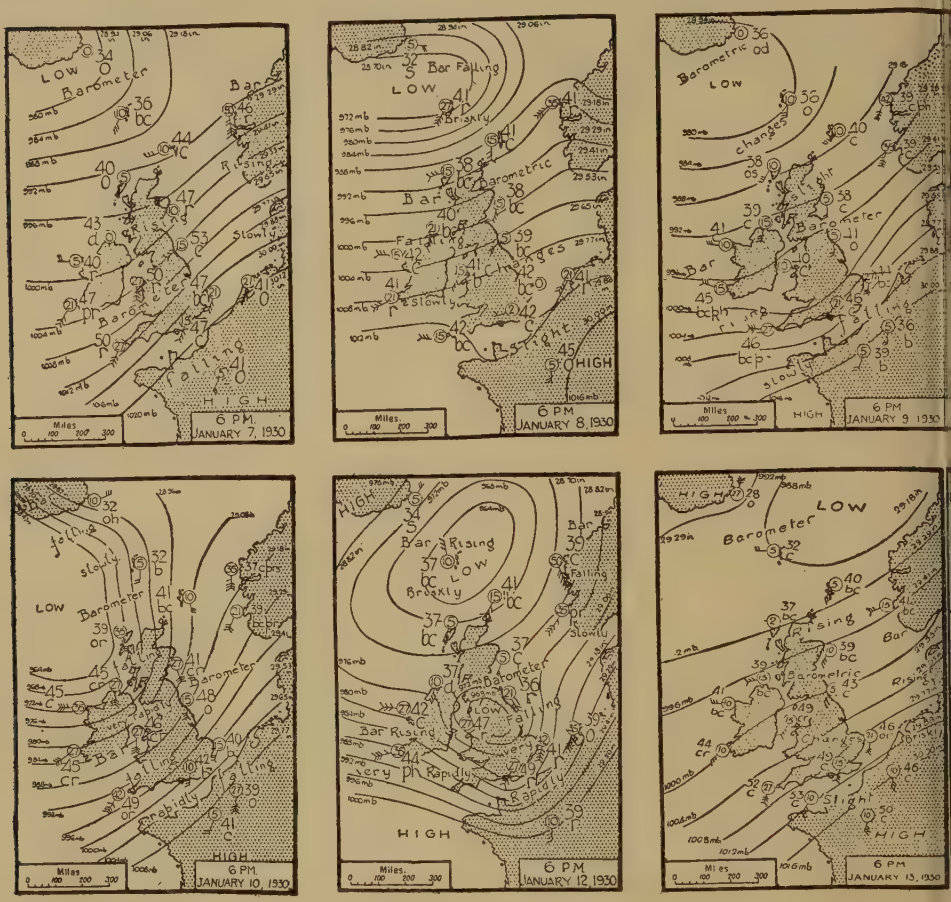


Chart I.

Showing the Winds Prevailing at the time of Occurrence of the Unprecedentedly Strong Flow of Water through Dover Straits in the customary ENE going Direction.

better than the contemporaneous units in the composite charts, by reason of small size, can do.

To complete the story, it is only natural that one should set down here tables giving the wind and sea observations as logged aboard the observing lightvessel at the time, for it is necessary to indicate under what adverse conditions the work was done. As a further and very useful illustration of the strength of the winds at the times in which

we are interested, and of the abrupt manner in which the change-over from a period of strong winds from the S.W. quadrant to the opposite state of affairs took place, I am able to quote data from the wind records made at Eastbourne and Falmouth. Such data as these have their special

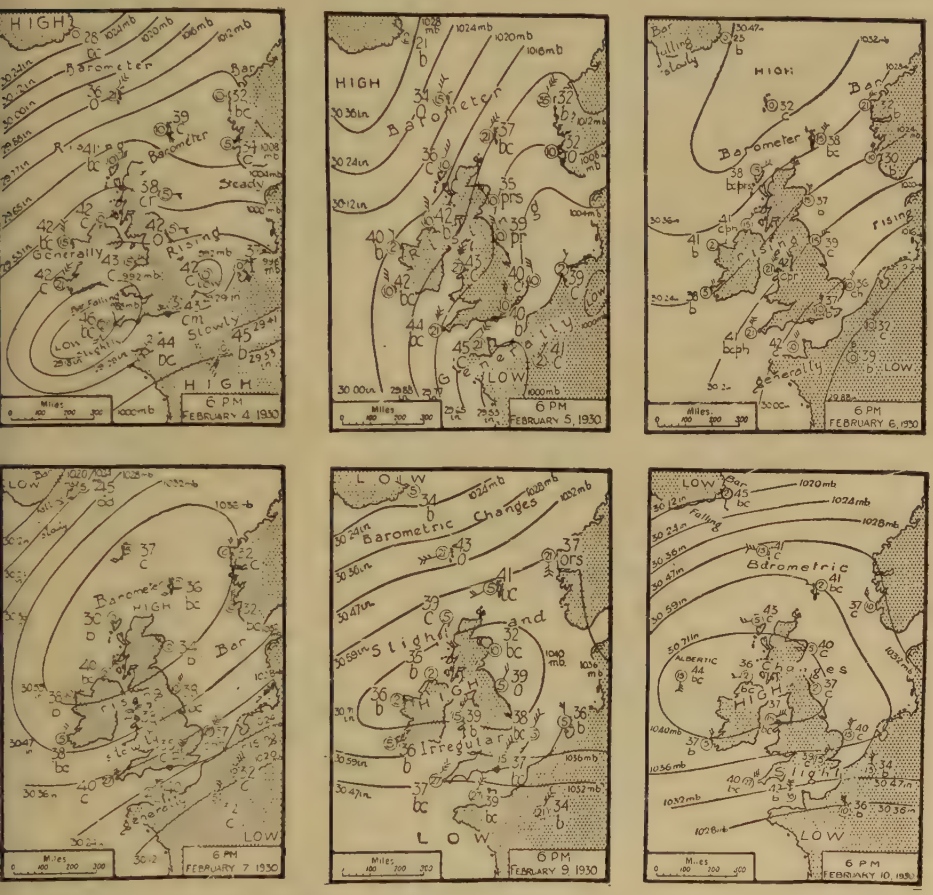


Chart II.

Showing the Winds Prevailing at the Time of Occurrence of the most Pronounced Reversal of the Customary ENE going Flow through Dover Straits.

value, for of course, whilst the synoptic charts give the necessary picture of the wind system over a wide area, they do not enable one to see what gusts took place and where. The lightvessel's own logged data serve to yield some idea of the local gusts, though to some extent in the Beaufort estimates of wind, and very obviously in the assessment of sea surface roughness, the personal equation has to be allowed for. The Eastbourne wind data from anemograph records help one to some extent

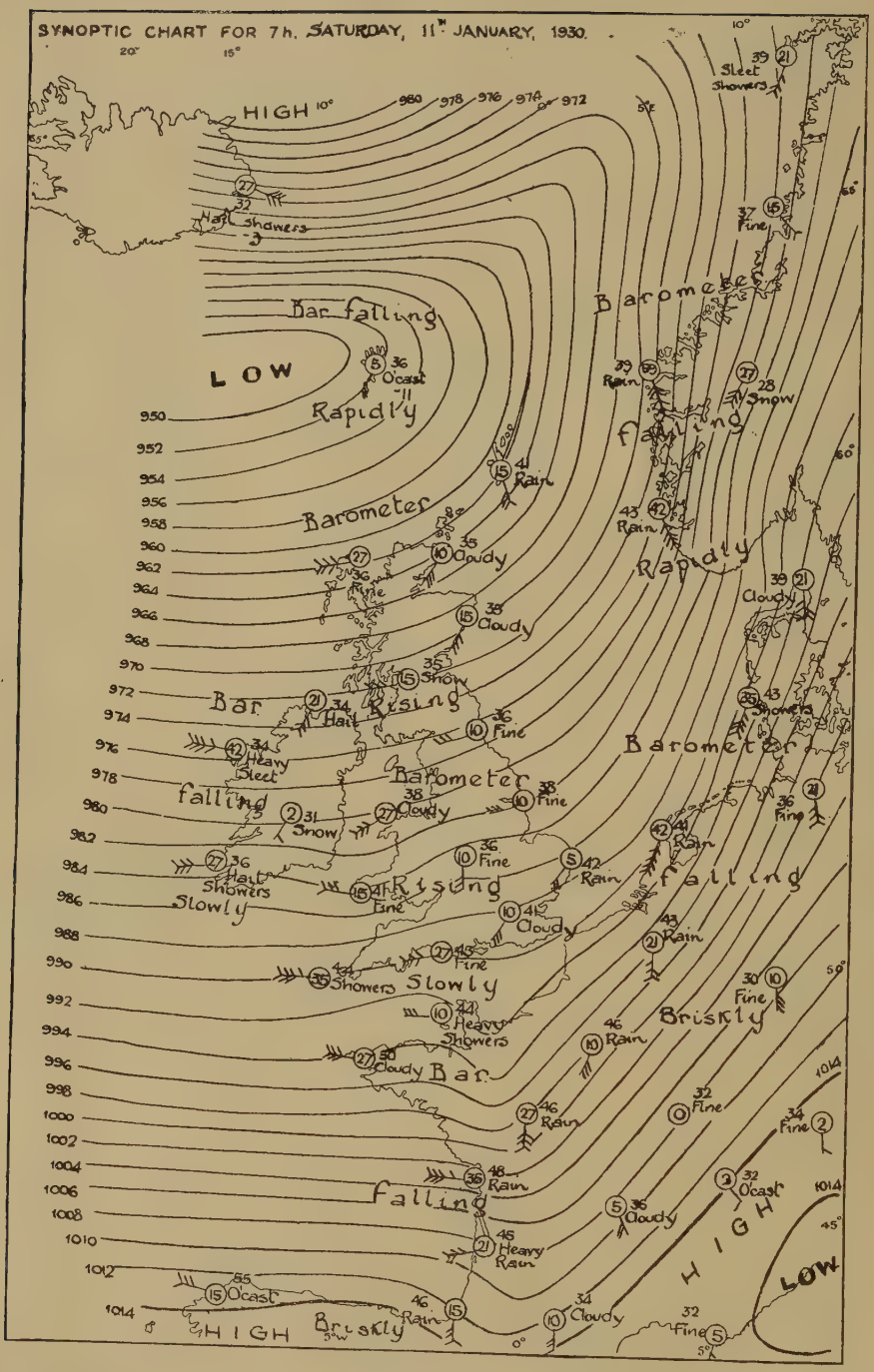


Chart. III.

Ideal Wind Distribution for the Promotion of an unusually Strong ENE going current through Dover Straits.

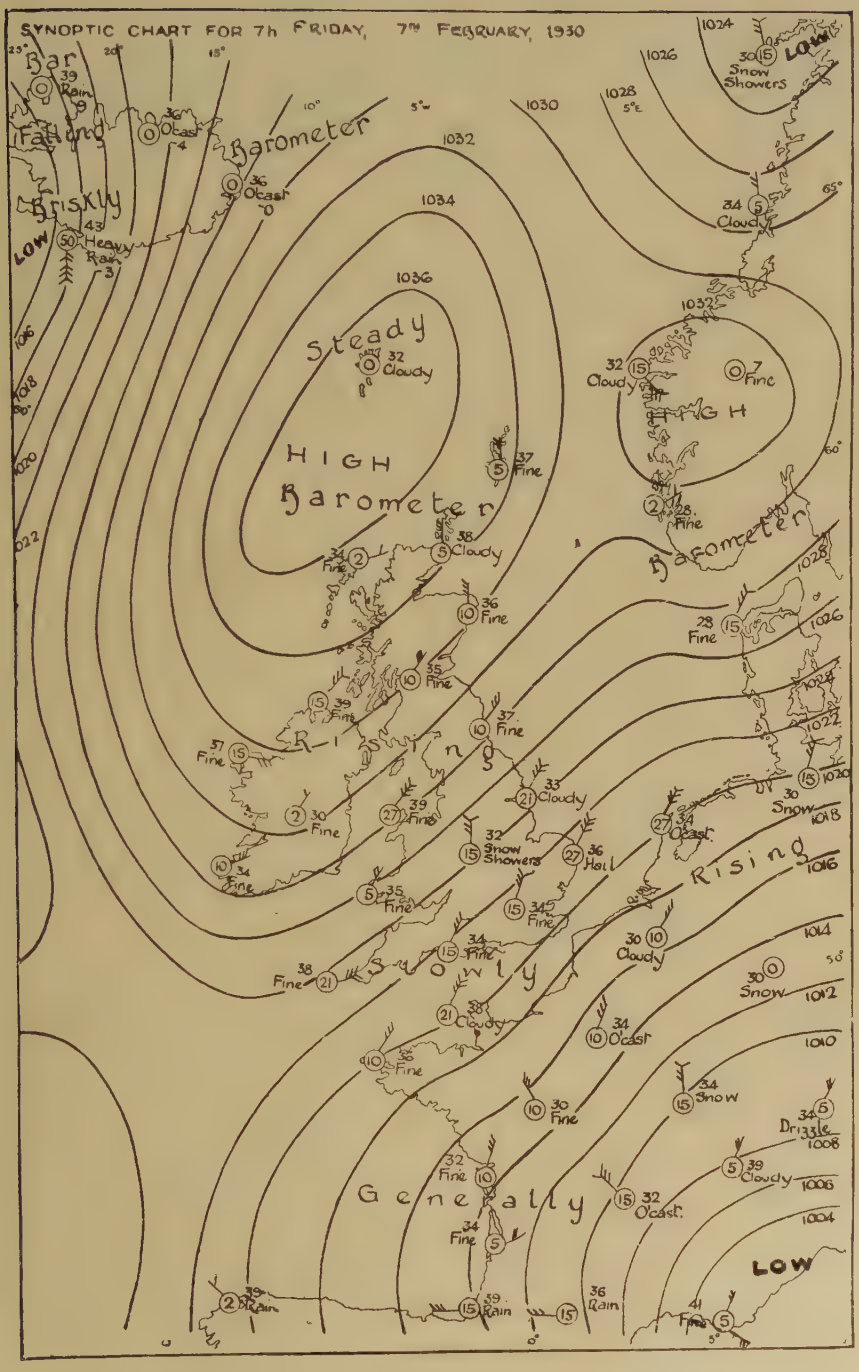


Chart IV.

Depicting an ideal Development of Wind Distribution most potent in Reversing the normal ENE going current through Dover Straits.

to check the Beaufort Scale entries of the lightship observers where necessary, it being difficult to place reliance on such estimates when the winds touch much more than force 7. It is not argued that the Eastbourne wind data constitute an ideal check on the Varne's own data, for the two places are some forty miles apart for one thing, and the

Table 1. Wind and Sea Particulars as logged aboard the Observing (The Varne) Lightvessel at the Time of Occurrence of the Strongest E.N.E. going Flow yet measured[1]).

(a) Immediately Prior to the Observation.

Date	Hour	Wind		Sea
		Strength	Direction	
8th January....	3 p.m.	5	W.S.W.	5
	6 p. m.	3	N.N.W.	4
	9 p.m.	2	N.W.	3
	Midnight	2	N.W.	3
9th January....	3 a.m.	3	W.N.W.	3
	6 a.m.	4	W.	3
	9 a.m.	5	W.S.W.	4
	Noon	6—7	W.S.W.	5
	3 p.m.	6—7	W.S.W.	5
	6 p.m.	7—8	W.S.W.	5
	9 p.m.	7—8	W.S.W.	6
	Midnight	7—8	W.S.W.	6
10th January...	3 a.m.	8—9	W.S.W.	6
	6 a.m.	5—6	W.	5
	9 a.m.	4—5	W.×N.	4

Residual Wind Computed from the above 15 Observations:— 22.1 miles per hour from S. 64° W. true.

[1]) The associated Indicator record is Fig. 1.

Varne is so much more exposed. There can be little doubt that the Varne observer's estimates of wind force may in some cases be somewhat excessive, but comment on them and on the sea disturbance scale number entries is reserved for the moment.

(b) During the Observation.

Date	Hour	Wind		Sea
		Strength	Direction	
10th January...	Noon	3	W.	3
	3 p.m.	4	W.	5
	6 p.m.	6	S.W.	6
	9 p.m.	6—7	S.W.	7
	Midnight	6—7	S.W.	7
11th January...	3 a.m.	7—9	S.W.	9
	6 a.m.	7—9	S.W.	9
	9 a.m.	5	W.	6
	Noon	5	W.N.W.	5
	3 p.m.	5	W.S.W.	5
	6 p.m.	5	W.	5
	9 p.m.	5	W.	5
	Midnight	5	W.	6
12th January...	3 a.m.	6	W.	6
	6 a.m.	6	W.	6
	9 a.m.	5	W.	6
	Noon	6	S.S.W.	7
	3 p.m.	6—7	S.S.W.	8
	6 p.m.	7—8	S.S.W.	9
	9 p.m.	10—12	S.S.W.	12
	Midnight	9—10	W.S.W.	10
13th January...	3 a.m.	8—9	W.	10
	6 a.m.	8—9	W.	9
	9 a.m.	6	W.	7

Residual Wind Computed from the above 24 Observations:— 27.0 miles per hour from S. 51° W. true.

Table 2. Wind and Sea Particulars as logged aboard the Observing (The Varne) Lightvessel at the time of Occurrence of what is much the Most Pronounced Reversal of the Customary E.N.E. going Flow yet measured[1]).

(a) Immediately Prior to the Observation.

Date	Hour	Wind		Sea
		Strength	Direction	
4th February ..	6 p.m.	4	W.	4
	9 p.m.	3	W.N.W.	4
	Midnight	3	W.N.W.	4
5th February ..	3 a.m.	2	N.W.	2
	6 a.m.	2	N.E.	2
	9 a.m.	2	N.E.	3
	Noon	4	N.E.	4
	3 p.m.	5	N.E.	5
	6 p.m.	5	N.E.	6
	9 p.m.	5	N.E.	6
	Midnight	5	N.E.	6
6th February ..	3 a.m.	5	N.E.	6
	6 a.m.	5	N.E.	5
	9 a.m.	5	N.E.	5
	Noon	3	S.E.	4
	3 p.m.	5	E.N.E.	4
	6 p.m.	5—6	E.N.E.	5
	9 p.m.	4—5	E.N.E.	5
	Midnight	3	E.N.E.	4
7th February ..	3 a.m.	4—6	N.N.E.	6
	6 a.m.	4—6	N.E.	6
	9 a.m.	4—6	E.N.E.	6
	Noon	5—6	E.	6
	3 p.m.	5—6	E.N.E.	6
	6 p.m.	5—6	E.N.E.	6

Residual Wind Computed from the above 25 Observations:— 13.8 miles per hour from N. 40° E. true.

[1]) The associated Indicator record is Fig. 2.

(b) During the Observation.

Date	Hour	Wind		Sea
		Strength	Direction	
7th February ..	9 p.m.	5—6	E.N.E.	6
	Midnight	5—6	E.N.E.	6
8th February ..	3 a.m.	6—7	E.N.E.	6
	6 a.m.	6—7	E.N.E.	6
	9 a.m.	5—6	E.N.E.	6
	Noon	5—6	E.N.E.	6
	3 p.m.	5—6	E.N.E.	6
	6 p.m.	5—6	E.N.E.	6
	9 p.m.	5—6	E.	5
	Midnight	5—6	E.	5
9th February ..	3 a.m.	6	E.	5
	6 a.m.	6	E.	5
	9 a.m.	6	E.	6
	Noon	6—7	E.	7
	3 p.m.	6—7	E.N.E.	7
	6 p.m.	6—7	E.N.E.	7
	9 p.m.	5—6	E.N.E.	7
	Midnight	5—6	E.N.E.	7
10th February..	3 a.m.	5—6	E.N.E.	7
	6 a.m.	5—6	E.N.E.	7
	9 a.m.	5—6	E.N.E.	7
	Noon	5—6	E.	6
	3 p.m.	6—7	E.	6
	6 p.m.	6—7	E.	6
	9 p.m.	5—6	E.	6

Residual Wind Computed from the above 25 Observations:— 25.8 miles per hour from N. 65° E. true.

The following table presents the relevant wind data from Eastbourne for the two periods in question:—

Table 3. Eastbourne. Particulars of wind force and direction[1]).

Date 1930	Hours			Electric Anemometer m. p. h.			Cup Anemometer		
	9.	17.	21.	9.	17.	21.	9 p.m. to 9 a.m.	9 a.m. to 9 p.m.	24 hours
Jan. 6th	[2]W.S.W.	[3]W.	[2]W.	x	9½	7.7	86.84	75.18	162.02
— 7th	[3]W.S.W.	[4]S.W.	[4]S.W.	10½	14	14	107.10	112.56	219.66
— 8th	[2]W.S.W.	[2]W.N.W.	[2]W.N.W.	7.7	x	x	92.00	52.50	144.50
— 9th	[4]S.W.	[5]S.S.W.	[4]S.S.W.	16	17½	14	157.30	152.40	309.70
— 10th	[2]W.N.W.	[2]W.S.W.	[4]W.S.W.	x	7.7	16	157.34	91.40	248.74
— 11th	[3]W.S.W.	[4]W.N.W.	[4]W.N.W.	11½	12½	14	178.55	170.36	348.91
— 12th	[4]W.N.W.	[5]S.W.	[8]W.N.W.	12½	23½	44	277.90	246.45	524.35
— 13th	[4]W.S.W.	[2]S.W.	[4]S.W.	16	x	16	117.88	94.30	212.18
— 14th	[3]S.W.	[2]W.S.W.	[3]S.W.	7.7	x	7.7	110.94	53.22	164.16
Feb. 3rd	[2]N.N.W.	[3]S.S.W.	[2]W.	x	10½	7.2	93.36	161.18	154.54
— 4th	[3]W.S.W.	[3]W.N.W.	[2]W.N.W.	10½	7.7	7.2	48.38	93.68	142.06
— 5th	[2]N.N.W.	[3]N.N.W.	[3]N.N.W.	x	10½	7.7	114.50	90.64	205.14
— 6th	[4]N.N.W.	[2]N.N.E.	[3]N.N.W.	14	x	11½	141.00	141.80	282.80
— 7th	[3]N.N.E.	[4]N.N.E.	[4]N.N.E.	10½	16	12½	115.80	135.60	251.60
— 8th	[4]N.E.	[5]E.N.E.	[3]N.E.	14	16	10½	185.30	137.80	323.10
— 9th	[6]E.	[5]E.N.E.	[4]E.N.E.	23½	19	16	103.18	202.12	305.30
— 10th	[5]E.N.E.	[4]E.N.E.	[3]N.N.E.	19	16	7.7	112.40	156.40	268.80
— 11th	[6]E.	[3]N.N.E.	[2]N.N.W.	23½	8.8	x	77.44	121.20	198.64

Attached Note. Jan. 12th, 1.30 p.m. Winds becoming very strong and reaching gale force during the afternoon and evening, and continuing until early next morning. Electric Cp Anemometer. "x" denotes less than 6.8 miles per hour.

It would be surmised that the winds prevailing at the western end of the Channel must be very important as influencing the urge of waters up Channel or the reverse. The following wind data from Falmouth Observatory are relevant:—

[1]) The small figures in the second, third, and fourth vertical columns are Beaufort numbers; the entries in the last three vertical columns denote the mileage run of the wind.

Table 4.

Relevant Wind Data from the Western End of the English Channel.

A. Daily Residual Winds at Falmouth.

(Each entry is a vector average computed from the original data supplied; these latter consisted of hourly anemograph differences which gave the wind in miles per hour from a true direction expressed to the nearest 5°. For present convenience the 24 daily values were grouped into the 16 main divisions of the compass and the resulting residual wind directions rounded off to the nearest 5°.)

Day of January, 1930:	Residual Wind:
6th	7.7 miles per hour from S. 65° W. true
7th	18.5 — - — — S. 25° W. —
8th	9.3 — - — — S. 85° W. —
9th	16.0 — - — — S. 35° W. —
10th	16.4 — - — — S. 35° W. —
11th	13.5 — - — — S. 50° W. —
12th	20.5 — - — — S. 75° W. —
13th	15.9 — - — — S. 40° W. —

Day of February, 1930:	Residual Wind:
3rd	7.9 miles per hour from S. 65° W. true
4th	8.7 — - — — S. 55° W. —
5th	11.4 — - — — N. 5° E. —
6th	10.0 — - — — N. 5° E. —
7th	13.5 — - — — N. 20° E. —
8th	14.7 — - — — N. 35° E. —
9th	16.8 — - — — N. 40° E. —
10th	16.5 — - — — N. 45° E. —

B. Relevant official Meteorological Office Data Relating to Extreme Wind Velocities.

(Extracted from the appropriate pair of Monthly Weather Reports.)

Place:	Highest Hourly Wind:				Highest Gust:		
Pendennis Castle (Devon)	Veer from North	Speed	Day	Hour	Speed	Day	Hour
January 1930 ..	240°	63 m.p.h.	12th	1700	102 m.p.h.	12th	1730
February 1930 .	90°	41 —	10th	1000	57 —	10th	1035
St. Mary's (Scilly Isles)							
January 1930 ..	260°	65 —	12th	1600	97 —	12th	1545

The observers on the Varne Lightvessel are asked to describe the state of the sea surface by reference to the following scale:—

Sea Disturbance Scale (Provisional).

Scale	Description	Height of waves in feet from crest to trough	Condition of Surface
0	Calm	—	Glassy
1, 2	Smooth	—	Rippled
3, 4	Slight to moderate	Under 5 feet	Rocks buoy or small boat Furrowed
5, 6	Rough to very rough	5 to 10 feet	Much disturbed; deeply furrowed
7, 8	High to very high	11 to 15 feet 16 to 35 feet	Rollers with steep fronts
9, 10	Phenomenal	36 feet and above	Precipitous; towering

Quite obviously their opinion of the state of the sea was very definite judging from the entries in Table 1, but it is quite clear that the scale numbers entered must be freely discounted though they are given here as logged to show how very unfavourable the working conditions were at the time. Perhaps too, one might be inclined to consider the wind strength rather overestimated at and around 9 p.m. on January 12th when the storm was at its height. Eastbourne logged force 8 at the time but it is almost certain that a gust touched force 12 at the Varne, judging by official records available[1]).

The wind and sea data given above shew in no doubtful manner under what rough conditions the observations of current under consideration were made, and it is worth re-affirming here that it is just when observing conditions are atrociously bad, that current measurements are particularly desirable.

It remains to comment briefly upon the two exceptional records in a way which will emphasise their important departures from the normal.

The most convenient procedure will be to set down the salient features in the form of terse statements as this will be less discursive and more convenient in displaying comparisons.

Residual Currents.

Three Year Mean:— 2.7 miles a day towards N. 34° E. true.

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[1]) E. g. Gusts exceeding 75 miles per hour (Beaufort No. 12) were recorded officially ashore at the time (Monthly Weather Report for January, 1930).

Previous Maximum E.N.E. going Flow[1]) (November 21st to 24th, 1928):— 17.7 miles per day towards N. 31° E. true.
Present Maximum E.N.E. going Flow (January 10th to 13th, 1930):— 21.0 miles per day towards N. 50° E. true.
Previous Most Pronounced Reversal (December 26th to 30th, 1927):— 11.9 miles per day towards S. 29° W. true.
Present Record Reversal (February 7th to 10th, 1930):— 12.9 miles per day towards S. 51° W. true.

Corresponding Stream Data.

Mileage Run of Flood Stream[2]) (3 year mean):— 5.63.
— — - Ebb Stream (3 year mean):— 4.28.
— — - Flood Stream (Present Maximum E.N.E. going Flow):— 13.15.
— — - Ebb Stream (Present Maximum E.N.E. going Flow):— 2.65.
— — - Flood Stream (Present Maximum Reversal):— 1.59.
— — - Ebb Stream (Present Maximum Reversal):— 8.04.
Possible Maximum Flood Stream Speed[3]) (3 year mean):— 1.47 knots.
— — Ebb Stream Speed (3 year mean):— 1.12 knots.
— — Flood Stream Speed (Present Maximum Flow):— 3.44 knots.
— — Ebb Stream Speed (Present Maximum Flow):— 0.69 knots.
— — Flood Stream Speed (Present Maximum Reversal):— 0.42 knots.
— — Ebb Stream Speed (Present Maximum Reversal):— 2.10 knots.

If we pay regard to the sum total of the to and fro water movements past the lightvessel each tidal cycle, we see that:—

Maximum E.N.E. going Flow	:	Most Pronounced Reversal	:	Three Year Mean	:: 15.79 : 9.63 : 9.91.
					i. e. :: 164 : 100 : 103.

Looked at in one way then, we may say that on an occasion of pronounced reversal, the Ebb gains at the expense of the Flood, their sum

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[1]) Not published.
[2]) E.N.E. going stream.
[3]) Mileage run $\times \frac{\pi}{12}$; British Admiralty log-ship measurements of the Spring Tide stream rates are available for comparison (**3**).

remaining about the same, whilst on an occasion of exceptionally strong E.N.E. going flow the Flood stream is increased by a very much greater accession of volume than can be supplied by any re-arrangement as it were between the two streams. It needs no brilliant reasoning to explain this; we need only to recall the conditioning distributions of wind. An extensive and persistent sweep of southerly winds over the entire bosom of the North Sea cannot possibly be pictured as driving more water before them than can spread away freely to the north. Thus one can easily picture a progressive tendency towards a lowering of the water level in the Southern Bight with consequent very favourable conditions for an unusually strong flow in of water through Dover Straits from the Channel. Let there also be southwesterly winds over the Channel and the conditions are enhanced. The point is that we can, under these circumstances, hardly conceive of an accumulation of water in the Straits, for the North Sea aspiratory effect will so easily prevail over the damming up effect at the southwestern end of the Straits due to the tendency for an accumulation there of wind urged water from the Channel.

In the opposite state of affairs, so far as winds are concerned, the damming up effect in the Southern Bight is readily pictured as much more important than is the water lowering effect in the eastern Channel.

Actually it has been noticed that at times of reversals the average water level in the Straits is raised, whereas at times of marked accessions of strength to the customary E.N.E. going flow, the average water level is lowered. At the times of our two present exceptional observations, the tide gauges at Dover and Boulogne were out of order so that illustrative data cannot be set down here. Still, the remarks just made, lead one to suppose that it is much less likely that the present unprecedented reversal should be exceeded in the future than that the abnormal E.N.E. going flow should be.

Acknowledgments.

Thanks are due and are here expressed to "The Times" for permission to reproduce the weather charts which appear in Charts I and II; to the Controller of H.M. Stationary Office for permission to reproduce the synoptic charts appearing as Charts III and IV; to the Meteorological Observer of the County Borough of Eastbourne (Mr. A. H. Hookham) for the wind data constituting Table 3; to the Superintendent of Falmouth Observatory (Mr. W. Tregoning Hooper) for the wind data upon which Table 4 is based; and to Mr. H. J. Garrood for the drawing of the Drift Indicator compass system which appears in the Appendix.

Zusammenfassung.

Es werden Beobachtungen über die Strömungen in der Strasse von Dover während der Monate November und Dezember 1929, Januar und Februar 1930 behandelt. Diese Beobachtungen, welche im Rahmen der laufenden englischen Untersuchungen über Restströme vom Varne-Feuerschiff aus in der Strasse von Dover gemacht werden, zeigen einen Zustand, der sehr beträchlich von den Verhältnissen abweicht, wie sie in den entsprechenden Beobachtungsperioden der drei vorangegangenen Jahre gefunden wurden. Während der ganzen drei Monate November, Dezember und Januar war der Einstrom des Wassers vom Englischen Kanal her in die Nordsee fast völlig ungehindert und $2^1/_2$ mal so stark als normal. Resultate wie diese können wohl geeignet sein, auf Probleme der Fischereiforschung angewendet zu werden.

Das Auftreten eines ungewöhnlich gut entwickelten Windsystemes von dem Typ, welcher den regelmässigen Strom nach E.N.E. begünstigt, ergab im Januar 1930 den anormal starken Strom von 21.0 Meilen pro Tag vom Englischen Kanal nach der Nordsee. Anfang Februar änderten sich die Windverhältnisse plötzlich, indem sich ein Windsystem des Typs entwickelte, welcher die Entstehung einer dem gewöhnlichen Strome nach E.N.E. entgegengesetzten Strömung ausserordentlich begünstigt. Eine anormal ausgeprägte Umkehr setzte ein, weshalb der Strom nun mit einer Geschwindigkeit von 12.9 Meilen pro Tag nach W.S.W. floss.

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(2) Carruthers, J. N. "A New Current Measuring Instrument for the purposes of Fishery Research." — Cons. Internat. Journal du Conseil. Vol. I, No. 2. 1926.

(3) Admiralty Publication. "The Tides and Tidal Streams of the British Islands". 1st edition 1909.

Appendix.

A Further Note on the Instrument with which the Observations were made.

The Drift Indicator was originally described in this journal (Vol. I, No. 2, 1926) and although its main features have in no wise been departed from since that time, yet a few alterations needing mention have been

made. These have been directed to one end only — to enhance the instrument's ability to "stand up to" the very rough usage for which it is intended, so ensuring that it shall not need to be brought away for repair more frequently say than every ten months or so. After being in use for this length of time, exposed to what is in a way a veritable sand-

Fig. 4. General view of the Drift Indicator.

blast, the brass cover becomes worn down to such an extent as to be almost puncturable by the finger. Hence one could not hope to have any one instrument at work continuously for more than a year — the maximum time yet achieved. Any reader interested is referred to the Writer's recent paper in the Rapports et Procès-Verbaux (Vol. LXIV, 1930, pp. 24 et seq.). There, a critique of the instrument's work is given, judged from what is held to be a rational viewpoint.

It is useless to contemplate employing in the continuous current

measurements necessary in fishery research, any instruments which cannot function under all the bad working conditions imposed. One has to choose between the use of current meters, which, though perfect from an instrument maker's point of view, cannot possibly survive really severe usage, and instruments which, though having shortcomings in

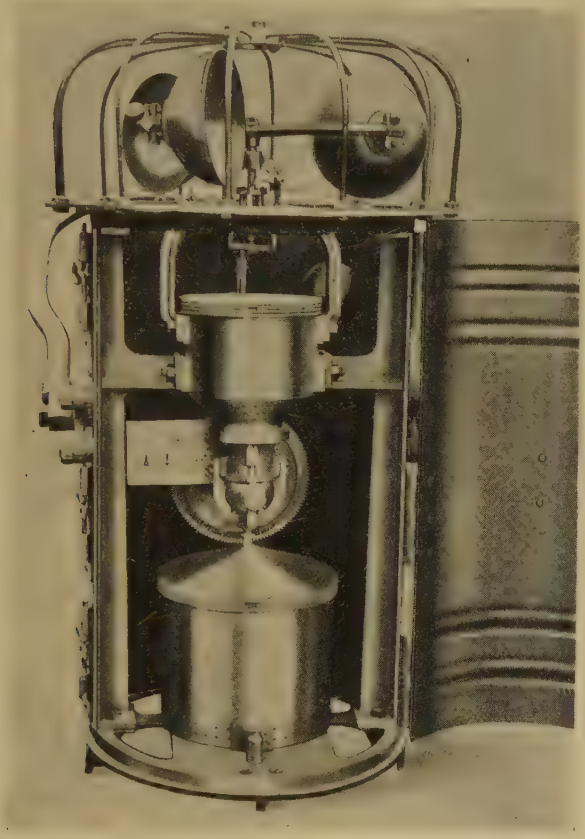
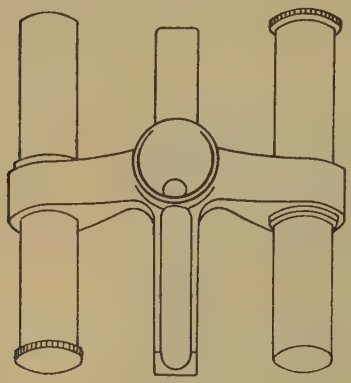


Fig. 5. View of the Interior of the Drift Indicator.

respect both of sensitivity and accuracy, can both do this and be operated by the personnel of lightvessels.

Now the Drift Indicator as described in this journal (1926) had a regrettable fault in the too frequent jamming of the balls in the large hopper. Balls consequently failed to drop, and too many observations were spoilt. This fault was soon completely remedied as follows. Instead of balls being carried round from the hopper into the delivery spout by means of three equidistant holes on the periphery of a rotating wheel

turning in a vertical plane at the bottom of a slot, the dropping of balls is now effected by a rotating brass solid sphere of ample size which occupies the present cone shaped bottom of the hopper. This sphere turns on a horizontal fore and aft spindle, and has three suitable equidistant holes on its surface in the vertical plane (perpendicular to the spindle) bisecting it; the rotation of this sphere gives adequate agitation to the balls in the hopper so preventing them from jamming. It is rare to have any trouble nowadays on this latter score.



The new mechanism can be seen in the picture reproduced above (see Fig. 5).

Two other new features are the following:—

Sliding inspection doors are now fitted (see Fig. 4) and the cups are much more conveniently and satisfactorily attached to the arms by means of winged screws. The rotator is now three armed instead of four armed, for reasons set down elsewhere (1 page 8). The dials seen in Figure 5 were fitted for a special reason and are not a feature of the instrument as ordinarily used or supplied. Similarly, the spherical object to be seen in Fig. 5 on the upper right hand side of the interior of the instrument, serves a special purpose, and is not a usual fitting. It is a device resembling a cistern ball valve, and has been employed to prevent rotation of the cups when the instrument is drawn out of the water.

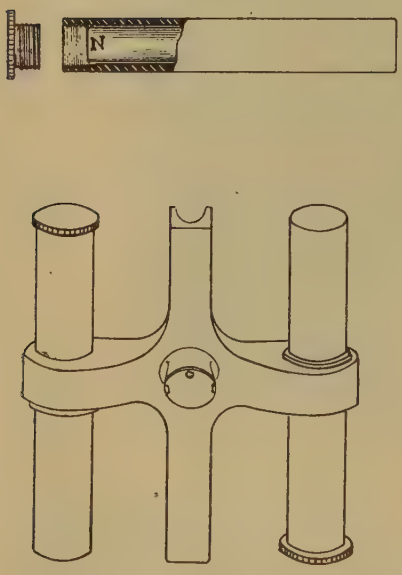


Fig. 6. The Vulcanite Tube Compass used with the Drift Indicator.

An exceptionally useful new feature concerns the chief accessory of the Drift Indicator — its compass. This compass, which has been in use since 1926, is shown in detail in Fig. 6 which is self explanatory.

Everything save the magnets and the agate cup is of vulcanite. These compass systems need practically no attention save for an initial filling of oil in the magnet tubes; new magnets can be put in as required, but this need not be necessary in the course of two years work. The compass-system weighs $1^3/_4$ ozs. (50 grams) with its magnets; $^3/_4$ oz. (25 grams) without them, and its magnet tubes are $2^1/_2$ ins. (63 mm.) long.

The entire Drift Indicator as at present in use, weighs about 77 lbs. (35 kg.) but to this has to be added the weight of the three or four 7 lbs. leads which are shackled into the fore and aft balancing bar before the instrument is put outboard for an observation. Thus, as it hangs out ready for use, the instrument weighs about $7^1/_2$ stones (47.5 kg.). The various dimensions of the Indicator as pictured in Fig. 4, may be judged from the statement that the vertical length of the main door is $19^1/_2$ ins. (49 cms.). The total length of the Indicator in the fore and aft line is about 34 ins. (86 cms.); its height, exclusive of the swing handle is about 28 ins. (71 cms.) whilst, with the swing handle held vertically, the overall height of the instrument is about 33 ins. (84 cms.).

Ein verbesserter Becher für das Standard-Netz.

Von

Dr. **H. Lissner**, Hamburg.

Als im Jahre 1925 das von C. H. Ostenfeld und P. Jespersen beschriebene Standardnetz für Planktonuntersuchungen[1]) von uns zum ersten Male benutzt wurde, stellte sich sehr bald heraus, dass die Entleerung des nicht abnehmbaren Bechers mit Unbequemlichkeiten verknüpft war, zumal an seinen Wänden stets Planktonorganismen haften blieben. Der Becher wurde daher in zwei Teile zerlegt, und hat nun eine Form ähnlich der, wie sie R. S. Wempenny beschreibt[2]). Er besteht aus einem oberen Teil (Fig. 1a), der drei Ringe zur Befestigung der Haltetaue trägt und an dem der Seidenbeutel mit einem Klemmring angeschlossen wird, und einem unteren Teil, dem eigentlichen Becher (Fig. 1b). Dieser wird an den Oberteil durch einen Bajonettverschluss mit zwei Zapfen (z) angefügt. Zur Sicherung des Verschlusses ist am unteren Becherteil eine Feder (f) angebracht, die in den Schlitz (s) für den einen der beiden Zapfen hineinpasst. Der Verschluss hat sich während der fünf Jahre, in denen der neue Becher in Gebrauch ist, als durchaus sicher erwiesen. Bei einem vorgeschriebenen Durchmesser von 75 mm hat der obere Becherteil eine Höhe von 58 mm, der untere von 80 mm, und der geschlossene Becher eine Höhe von 123 mm. Das Verbindungsstück des Oberbechers, das eine Gesamtlänge von 37 mm hat, ragt 15 mm in den Unterbecher hinein. Es besteht aus 1,5 mm starkem Messingblech und ist, zur Vermeidung unerwünschter Vorsprünge im Innern des Bechers, an seiner Oberkante schräg nach innen abgeschliffen, ebenso wie der obere Rand des Oberbechers (Fig. 1c). Dieser und der Unterbecher sind aus Messingblech von 2 mm Stärke.

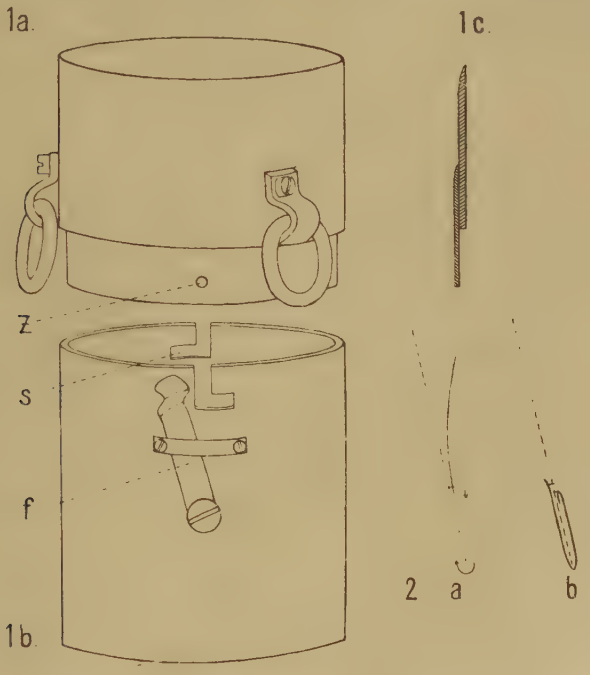
Da in der Regel noch ein Reservenetz mit einem zweiten Becher vorhanden ist, können beim Arbeiten mit dem Standardnetz beide Becher abwechselnd an einem Netze gebraucht werden, so dass, während

[1]) Publications de Circonstance, No. 84, Kopenhagen 1924.

[2]) Journal du Conseil, III, 1, Kopenhagen 1928.

der eine Becher mit dem Netze heruntergelassen wird, der andere geleert und frisch mit Seidengaze bespannt wird. Vor allem bei Stufenfängen in grösseren Tiefen wird damit eine erhebliche Beschleunigung der Arbeit erzielt.

Der Netzbeutel wird an den Becher mit einem Klemmring befestigt; diese Befestigungsstelle, die dem Drucke des Metalls ausgesetzt ist, wird



in der Regel durch einen Leinenstreifen geschützt. Es ist zweckmässig, hierfür feines, schon gewaschenes Leinen zu verwenden und es so zu befestigen, dass an der Innenseite der filtrierenden Fläche keine Vorsprünge und Taschen entstehen, in denen sich Teile des Fanges ansammeln können. Dies geschieht am besten, indem man einen Leinenstreifen von ungefähr 60 mm Breite zunächst innen, etwa 30 mm vom Rande entfernt, an der Seidengaze festnäht (Fig. 2a), ihn dann umschlägt und straff nach unten zieht, ihn schliesslich nach aussen umschlägt und sein Ende mit einer zweiten Naht an der Gaze befestigt (Fig. 2b). Die Lebensdauer des Seidenbeutels wird durch die Verstärkung wesentlich verlängert.

The Death of Fish in very Cold Winters.

By

Alf Dannevig.

The Flødevig Sea-fish Hatchery, Norway.

In a paper on the unusual mortality amongst fish in the North Sea during March and April 1929[1]), the authors express a desire for more information bearing on the phenomena described. Though I am wholly unacquainted with the matter as far as the North Sea is concerned, nevertheless my observations of similar phenomena on the Skagerrack coast of Norway will perhaps help to enlighten the question further.

The particulars mentioned here will be found in my report for the Hatchery, printed in "Årsberetning vedk. Norges Fiskerier 1924, 1 Hefte". A more complete report in English on that problem, and on the effect of the cold winter, 1924 on the propagation of our common fishes is now in the press[2]).

Dead fish are commonly to be found in very hard winters on the Skagerrack coast of Norway. The species mostly encountered are young specimens of the Cod, the Pollack, the Green-cod, some Labridae and often large specimens of Conger. The dead fish occur when the sea-water has attained a temperature of about one degree below zero. From experiments at the Hatchery it has been found that this temperature may be critical for the Cod. Moreover, the investigations of Professor Dr. S. Schmidt-Nielsen have shown that the freezing point of the blood of some teleostean fishes lies between 0.5° and 1° C. below zero. It is therefore quite reasonable to claim the coldness of the water as the direct cause of death when the sea temperature falls as low as one degree below zero.

On 2nd March, 1923, the temperature of the sea-water at Flødevigen, 1 m. below the surface, was —1.1° C., and near the bottom, at 15 m., it was as low as —1.4° C. That day I noticed dying specimens of *Labrus*

[1]) J. R. Lumby and G. T. Atkinson. J. du C., IV, 3, 1929.

[2]) Report on Norwegian Fishery and Marine Investigations Vol. III, No. 10.

rupestris and *Raniceps ranius* coming up to the surface, and dead cod were reported from waters in the neighbourhood.

From the temperatures given for the North Sea areas in question, it appears, however, that such low temperatures were not recorded. But it must be remembered that in this connection we are concerned with the very lowest temperature that occurred, and it would be by mere chance that that temperature were observed. In the region most affected, the Terschelling Bank, there were no temperature measurements from 17th February until 2nd March (Fig. 1 in the paper cited), at a time when, near the Jutland coast, we had the lowest sea temperature observation, viz., —1.8° C. (on 23rd February). The experiences I have had in our waters incline me to the belief that the temperatures in the North Sea, in the areas in question, may have been for a short space of time as low as one degree below zero — and consequently fatal to the species mentioned.

On the Skagerrack coast of Norway the fatal temperatures seldom last for more than a few days, and occur in the outer part of the skjærgård only when the Baltic current is pressed against the coast by the wind. If the wind is off-shore, the fatal temperatures will not occur near the coast. Furthermore, in the deep Skagerrack the fish will not be harmed, owing to the great depth of water which affords an avenue of escape. In the inner skjærgård and in the fjords the surface water will be diluted with fresh water from the rivers, and this more or less brackish water will freeze and isolate the underlying, genuine sea-water from the atmosphere. Within the fjords dead fish are never reported, except from some very isolated fjords where the bottom layers are rendered poisonous by sulphuretted hydrogen. When dead fish appear there, the phenomenon is always accompanied by a disagreeable smell from the water.

It may be worth mentioning, too, that towards the end of February 1929, when drift ice filled a great part of the Skagerrack, the pilots and the officers of some of the steamers crossing reported that the currents were quite opposite to the normal in direction. Along the west coast of Jutland the current flowed southwards, while along the Norwegian coast of the Skagerrack it flowed towards the North-east. Thus it may be possible that the cold south-going current paid a visit to the Terschelling Bank.

It is an open question whether death can be brought about by a sudden change of temperature, if the critical temperature is not attained. As regards the grown cod at least, I have never observed anything of that nature. At the Hatchery, the temperature of the sea-water may

vary 5 degrees or more in a few days, without harm to the cod kept in captivity. Occasionally the spawning cod-fish at the Hatchery have been exposed to temperatures near —1° C., and some of them have succumbed; but the rest, however, seemed to be none the worse when brought under more favourable temperature conditions.

The phenomenon of the accumulation of fish, in cold winters, in the deeper waters is well known to the fishermen of our coast; and at the same time the shallow waters become quite denuded of fish.

On what does the Catch of undersized Fish depend?

First Report on the Polish Research on Saving-Trawls.

By

Joseph Borowik.

Department of Fishery Economics, National Institute for Scientific Agriculture, Bydgoszcz, Poland.

1. The problem of Savings gear.

The name "savings gear" (savings trawl) has been accepted for all that fishing gear which makes possible the escape of small, unmarketable, undersized fish.

The determination of "the proper size of fish" is of the greatest importance for the construction of protective gear, and of course "the proper size" depends on the species of fish, the method of catching and the biological, as well as the commercial, points of view. The rate of growth and the time of sexual maturity on the one hand, and the conditions of the market on the other, undergo great fluctuations not only with regard to the species in general, but with regard to one given species in a certain region and at a certain period of catching.

Consequently we see that the construction of a savings gear touches on a great many fishery problems and requires comprehensive research both on the technique of fishing and the biology of the fish; in the first place it should take into consideration the character of the stock with regard to the various year-classes and the rate of growth.

One cannot expect to invent some miraculous protective gear which would work under all conditions and for all species of fish; we are not therefore trying to invent a universal protective gear, but our aim is so to modify the industrial fishing gear that in certain conditions it would allow the escape of certain fish of pre-determined size.

There is no instrument which can catch "the whole composition of the stock of fish" present at the place of operation of the fishing gear. When studying the construction of various types of instruments for industrial fishing we are struck by the fact that the world over fisher-

men have been using fundamentally the same instruments and that in spite of considerable climatic, hydrographic, racial and cultural differences they have been catching fish in the same way — merely the details differ. One of the fundamental characteristics of fishing gear is the ability to "sift" all that the fisherman does not require; the instruments are endowed with a sort of selective ability. Very often when fishing for species which differ greatly with regard to size and conditions of existence, fishermen use instruments of the same type: e.g. fishing for flat fishes, herring, cod, either with trawls, or using fixed nets for the same purpose. The trawl and the net remain, in a general way, the same; but, according to their purpose, there are changes in the size of mesh, the thickness of thread, the method of using and so on.

Consequently we can see clearly why a protective gear can be constructed merely by introducing some changes into the ordinary industrial fishing gear, by modifying its selective capacity in relation to the fish of which the size has been determined as "unmarketable" or immature. These depend to a certain degree on the size of mesh, the thickness of thread and the method of using the instrument.

Before we propose any changes in the construction of the fishing gear, we must get a clear conception of how the various factors influence the changes in the selective ability. There are three fundamental categories of change which can be introduced in the construction of the fishing gear and which ought to be carefully examined with regard to the influence which these changes bear on the composition of the catch. They are:—

1) changes in the size of the mesh,
2) changes in the distribution of the parts of the gear which have various sizes of mesh,
3) changes arising from the method of using the gear, especially as regards:—
   a) the speed,
   b) the width of the instrument.

Of course things work the other way also: the composition of the catch and the conditions of the locality play an important part by stressing or attenuating the selective ability of the fishing gear. When studying the changes in the structure of the gear we should strive to do our comparative experiments under similar conditions of stock and locality. If we then introduce just one change in the construction of the gear and conduct analytical research concerning the catch, we can elucidate gradually and slowly the part played by the various factors.

On the basis of such experiments alone shall we be able to elaborate accurately, and in detail, this or that plan for modification of the industrial fishing gear, aimed at an increase of their protective characteristics in relation to a given species and a given region. We also should take into consideration the principle that a savings gear should give catches which are satisfactory from the industrial point of view: in other words, the changes that are to be proposed should not appreciably lower the income of the fisherman, nor increase the costs of fishing gear and the working of the boats.

In order to obtain satisfactory data we must illustrate in detail the character of the various types of industrial fishing gear that have been used heretofore.

2. Research in Poland.

Research on savings gear which was started before the war was concerned for a long time with the trawl constructed by Captain Ridderstadt, proposed by the Swedish scientists and described for the first time by Gustav Ekman in 1916 (1).

Before the war, Prof. Baranow (2, 3, 4), of Russia, had not only proved the principle that for every size of mesh there is a corresponding size of fish, but he also tried to compute the "composition of the stock" basing it on the mathematical analysis of the results of the catch obtained by several nets with various sizes of the mesh.

The researches of Henking and Fischer (5) in the Baltic, conducted approximately at the same time, did not yield any convincing results.

Lately, owing to the interest which the matter of protective fishing gear has raised in the International Council for the Exploration of the Sea, research on the construction of "savings gear" has been taken up again, and we can distinctly perceive the direction it has taken. The works of Russell (6), Bowman (7, 8), Davis (9) and lately of Tesch (10) tend to prove the close interdependance of the size of the mesh and the composition of the catch.

It is interesting that in his works Bowman repeats almost literally the postulate expressed fifteen years ago by Prof. Baranow, concerning the close relation of the mesh and the size of fish caught.

Thus we may accept as certain that the size of the fish caught depends primarily on the size of the mesh used in the netting material. Therefore it is necessary for research on protective fishing gear to determine at the very beginning this relation for every species and every region having different morphological, hydrographical and biological characteristics.

In Poland research on savings fishing gear was started in 1927. At that time the close relation between the size of the mesh and the size of the fish caught had not yet been generally ascertained, so our research at first aimed only at the determination of the extent to which Prof. Baranow's postulates had a universal application. Later, in connection with the negotiations which were started in 1928 for the protection of fish in the Baltic, an attempt was made to throw light on the harmfulness of the fishing gear which till then had been in use. Finally, research on the construction of protective fishing gear was added when a representative of Poland was elected member of the Committee on Protective Fishing Gear.

These researches have so far brought abundant data illustrating not only the character of the industrial catches but elucidating in full detail several problems of construction of protective fishing gear — especially:

1) The dependence of the composition of the catch on the size of the mesh.
2) The significance of the various parts of a trawl for the escape of small fish.
3) The influence of the composition of a catch on the protective ability of the gear.

Experiments were also made on the dependence of the size of fish caught on the shape of the mesh and the thickness of the thread: observations of the influence of the speed of trawling on the composition of the catches, and so on. All these researches, as well as those concerning the construction of saving gear, are still being made, and some of the results obtained are not yet ripe for discussion.

In the present paper I intend to present summarily the results obtained in the three above directions. A detailed discussion of this material will be published in Memoirs of the Polish Institute of Scientific Agriculture.

3. Fishing conditions in the Polish Baltic (Gulf of Dantzig).

Polish research has been conducted exclusively on flat fish in the Polish territorial waters, near the peninsula of Hel and in the adjoining parts of Dantzig Bay. According to local regulations, the normal size limit for the plaice (*Pleuronectes platessa*) and the flounder (*Pleuronectes flesus*) is 18 cm.; for *Pleuronectes limanda* and *Rhombus maximus* there are no restrictions. There is also a regulation on the Polish coast determining the size of the mesh of fishing gears: for flounder trawls it has

been temporarily set at 50 mm. There arose, however, great difficulties in putting this regulation into practice. It has become necessary to allow the use of instruments with smaller meshes for catching the small fish, bull head — (*Zoarces vivipara*), found in the same waters as the flounder. Furthermore, the fishermen argued that the 50 mm. size of the mesh would not allow any profit to be drawn from fishing in Dantzig Bay, owing to the scarcity of fish of the requisite size. Consequently a rigorous enforcement of that experimental regulation of the size of the mesh was soon abandoned, and we find in the bay of Dantzig trawls of all sorts of mesh, from 18 to 24 mm. up to 45 and 50 mm. This provided abundant data regarding the character of the mesh in its relation to industrial fishing.

In regard to the fishing gear, and especially trawls, used in Dantzig Bay, there are two fundamental types:—

1) The first, of local origin, made by the fishermen themselves of cotton netting material in the shape of an ordinary cuneiform sack with an upper rope five metres long, and with 140 meshes in the front part and 85 meshes in the cod-end.
2) The second resembles the trawls used by motor cutters in the North Sea, which are described by Davis as frequently used on the Eastern Coast of England. It is a miniature trawl built after the fashion of those used on steam trawlers: the upper rope is 11 metres long: the front part contains 170 meshes in width. These trawls came to Poland from the West and are furnished ready-made from the factory in Altona. They are made of hemp, have meshes of 45 and 50 mm. size, and differ in shape from the first type mainly through being equipped with side wings.

It should be added that all trawls used in Dantzig Bay have always 110 to 140 metres of rope placed between the wings of the trawl and the boards, with bunches of "sea-grass" attached. They remind one of the Vigneron Dahl system.

In both fundamental types of trawl we find a variety of meshes and thread. The majority of trawls have similar dimensions of mesh; there are, however, trawls which have a gradual transition from large meshes in the front part to smaller meshes in the cod-end.

There were eleven types of trawl for which we obtained various results as to catch. The experiments were conducted at a time and in such regions where it was possible to obtain exclusively flat fish of all the four species; and since the plaice (*Pleuronectes platessa*) and turbot

(*Rhombus maximus*) appear very scantily, we have concentrated our attention chiefly on the flounder (*Pleuronectes flesus*) and dab (*Pleuronectes limanda*).

For the experiments the observer made voyages in an industrial fishing cutter and took an average sample from every haul, the sample containing about 20 kg of fish. The measurements were made for the most part on the deck: in cases where the otoliths were to be taken for the determination of the age, or of the rate of growth, the work was done in the coastal laboratory of the Department of Fishery Economics at Hel.

In 1927 we collected data on the general conditions of fishing, with especial regard to the gear used and the regions frequented; a detailed programme of research was laid out and the preliminary research finished. In 1928 abundant data concerning the relation between the size of the mesh and the composition of the catch was collected and discussed, the summarised results of this research are presented in the section below. In 1929 the research on the significance of the various parts of the trawl for the escape of undersized fish was finished, and the results of those experiments are presented in Sections 5 and 6.

4. The dependence of the composition of the catch on the size of the mesh.

The results of an analytical study of the measurements of fish caught with trawls of 30, 40, 43, and 45 mm. meshes are presented in two tables (I and II) both for *Pleuronectes flesus* and for *Pleuronectes limanda*. In the upper part of the tables we have the number of fish of different sizes calculated in the proportion of one per mille of fish caught by a given trawl. For every dimension the number of undersized fish is also given.

At the bottom of each table the results of the same experiments have been presented in another way. Taking the quantity of commercial fish caught as 1000, the proportion of undersized fish caught has been calculated and the computations were made both in relation to the 18 cm size, now obligatory in the Polish waters, and that of 20 cm. which was proposed in one of the international schemes for the protection of flat fish in the Baltic.

The upper computations are very expressive, especially when we draw the corresponding curves; the lower ones are easy to read and do not require any special explanation, since they show quite plainly the decrease of the quantity of small fish in proportion to the increase of the size of the mesh. If the size of the mesh is changed from 30 to 45 mm.,

Table I. Flounder (*Pleuronectes flesus*).

A. Changes in composition of the catch, depending on the size of the meshes used.

The size of meshes	Size of fish in cm....	to 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(5533 fish from	Size frequencies in $^0/_{00}$	23	38	65	91	140	173	173	107	66	35	21	15	13	9	31
15 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	23	61	126	217	357	*530*	703	810	876	911	932	947	900	969
II. 40 mm.																
(3227 fish from	Size frequencies in $^0/_{00}$.....	..	1	1	12	40	105	211	195	187	95	52	35	21	14	31
15 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	..	1	2	14	54	159	370	*565*	752	847	899	934	955	969
III. 43 mm.																
(583 fish from	Size frequencies in $^0/_{00}$.....	..	2	3	12	60	97	200	204	190	84	48	40	12	12	36
4 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	..	2	5	17	77	174	374	*578*	764	852	900	940	952	964
IV. 45 mm.																
(1304 fish from	Size frequencies in $^0/_{00}$.....	..	2	..	1	12	33	108	128	225	165	95	70	50	26	85
12 hauls measured)	The sum of fish below the given size in $^0/_{00}$	..	..	2	2	3	15	48	156	284	*509*	674	769	839	889	915

B. The Quantity of Flounder of unmarketable size kept by trawls with various meshes, computed in proportion to 1000 full sized fish caught (10647 fish measured from 46 hauls).

Trawl with meshes of	Commercial size 18 cm	Commercial size 20 cm.
30 mm.	1127	4578
40 mm.	189	1298
43 mm.	210	1369
45 mm.	54	526

Table II. Dab (*Pleuronectes limanda*).

A. Changes in composition of the catch depending from the size of the meshes used.

The size of meshes	Size of fish in cm....	to 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm. (2520 fish from 15 hauls measured)	Size frequencies in ‰	137	102	85	68	107	116	106	74	59	45	20	17	10	12	42
	The sum of fish below the given size in ‰	..	137	239	324	392	*499*	615	721	795	854	899	919	936	946	958
II. 40 mm. (1174 fish from 15 hauls measured)	Size frequencies in ‰	1	5	9	18	59	89	176	198	164	95	49	23	15	15	84
	The sum of fish below the given size in ‰	..	1	6	15	33	92	181	357	*555*	719	814	863	886	901	916
III. 43 mm. (288 fish from 15 hauls measured)	Size frequencies in ‰	..	..	3	31	52	101	191	194	177	90	37	49	11	18	46
	The sum of fish below the given size in ‰	..	..	..	3	34	86	187	378	*572*	749	839	876	925	936	954
IV. 45 mm. (866 fish from 12 hauls measured)	Size frequencies in ‰	1	5	1	19	28	83	137	150	158	95	64	36	18	20	185
	The sum of fish below the given size in ‰	..	1	6	7	26	54	137	274	424	*562*	677	741	777	795	815

B. The Quantity of undersized Dab kept by the trawls with various sizes of meshes; computed in proportion to 1000 full sized fish caught (4857 fish measured from 46 hauls).

Trawl with meshes	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	1597	3878
40 mm.	221	1247
43 mm.	230	1336
45 mm.	158	733

the range of the changes with 18 cm. size of fish is tenfold, and with 20 cm. size of fish a fivefold decrease of the number of undersized fish.

We should add, however, that trawls with 30 and 40 mm. meshes belong to the type of ordinary cuneiform sacks which we called "local trawls" and trawls with 45 and 43 mm. meshes belong to the type which we agreed to call "the normal trawl". Also it should be added that the trawl with 40 mm. meshes was made of thin cotton, in consequence of which the resistance of the net was much smaller and the gear had to work at a much greater speed, which would explain its retention of small specimens of common dab.

The last feature which strikes us when we compare the two tables concerns the problem of the influence of the stock on the composition of the catch. The presence of fish of various sizes in catches made with the same trawl and in the same locality varies greatly according to the species of fish. Since we are dealing with related species, which differ very little in their rate of growth, the different action of the same gear in regard to the flounder and dab can be explained simply by the fact that in the catches of dab (*Pleuronectes limanda*) the younger year-classes were represented in greater numbers.

If we take all these things into consideration and try to evaluate the fishing gears used in the Polish fishery from the point of view of the protection of flat fish, we must state in the first place the quite obvious harm done by the 30 mm. mesh trawl: it is undoubtedly an instrument of destructive fishing. On the other hand the 43 mm. mesh trawl can be considered as effecting a saving, if the commercial size limit is 18 cm.

In fishing conditions on the Polish coast a trawl of 45 mm. seems to be rather wasteful, because, while keeping a minimal quantity of undersized fish, it undoubtedly allows the escape of full sized fish. Experiments conducted in 1930 with the double covered trawl have proved these ideas to be true. It is obvious that, were we to change the commercial size to 20 cm., the whole matter would be different, but this cannot be taken into consideration on account of industrial difficulties, because fish of the 20 cm. size can form but a small part of the catch.

5. The importance of the front part of the trawl for the escape of undersized fish.

The third table presents the results of experiments with trawls which had even meshes in the cod-end and different, i.e. larger or smaller, ones in the front part or in the wings. There are three series of possible computations:—

Table III. The importance of the front part (wings) of the trawl for the escape of undersized fish.

Flounder. A. Trawls with 30 mm. cod-end meshes and 30, 35—40 mm. and 50 mm. front part meshes. Autumn 1928.

Meshes in front part	Size of fish in cm....	to12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(5533 fish measured from 15 hauls)	Size frequencies in ‰	23	38	65	91	140	173	173	107	66	35	21	15	13	9	31
	The sum of fish below the given size in ‰	..	23	61	126	217	357	530	703	810	876	911	932	947	900	969
II. 35—40 mm.																
(3967 fish measured from 19 hauls)	Size frequencies in ‰	14	10	24	43	100	162	196	166	137	63	31	15	9	9	21
	The sum of fish below the given size in ‰	..	14	24	48	91	191	353	549	715	852	915	946	961	970	979
III. 50 mm.																
(409 fish measured from 10 hauls)	Size frequencies in ‰	20	20	50	66	64	122	98	115	110	54	63	41	34	44	99
	The sum of fish below the given size in ‰	..	20	40	90	156	220	342	440	555	665	719	782	823	857	901

Number of undersized Flounder held by various trawls in proportion to 1000 full sized fish caught (based on the measurements of 9909 fish from 44 hauls).

In the front part	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	1127	4578
35—40 mm.	545	2508
50 mm.	522	1249

B. Trawls with 40 mm. cod-end meshes and 30, 40, and 42 mm. front part meshes.

Front part meshes	Size of fish in cm....	to12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(846 fish measured from 4 hauls)	Size frequencies in ‰	19	11	38	40	84	134	217	174	163	55	20	19	9	9	8
	The sum of fish below the given size in ‰	..	19	30	68	108	192	326	543	717	880	935	955	974	983	992
II. 40 mm.[1])																
(3227 fish measured from 15 hauls)	Size frequencies in ‰	..	1	1	12	40	105	211	195	185	95	52	35	21	14	31
	The sum of fish below the given size in ‰	..	..	1	2	14	54	159	370	565	752	847	899	934	955	969
III. 42—45 mm.																
(1929 fish measured	Size f...															

In the front part	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	485	2765
40 mm.	189	1298
42—45 mm.	126	1370

C. Trawls with 45 mm. cod-end meshes and 30, 45 and 50 mm. front part meshes.

Meshes in front part	Size of fish in cm....	to 12	13	14	15	16	17	18	19	20	21	22	23	24	25	26 up
I. 30 mm.																
(1356 fish measured	Size frequencies in $^0/_{00}$.....	3	5	15	47	63	92	212	195	182	80	56	21	18	9	2
from 6 hauls)	The sum of fish below the given size in $^0/_{00}$	..	3	8	23	70	133	225	437	632	814	894	950	971	989	998
II. 45 mm.																
(1304 fish measured	Size frequencies in $^0/_{00}$.....	..	2	..	1	12	33	108	128	225	165	95	70	50	26	85
from 12 hauls)	The sum of fish below the given size in $^0/_{00}$	..	..	2	2	3	15	48	156	284	509	674	769	839	889	915
III. 50 mm.																
(767 fish measured	Size frequencies in $^0/_{00}$.....	..	..	4	..	14	27	98	99	228	188	111	75	47	35	74
from 8 hauls)	The sum of fish below the given size in $^0/_{00}$	..	..	..	4	..	18	45	143	242	470	658	769	844	891	926

Number of undersized Flounder held by various trawls in proportion to 1000 full sized fish caught (based on the measurements of 342 fish from 62 hauls).

In the front part	Commercial size 18 cm.	Commercial size 20 cm.
30 mm.	288	1710
45 mm.	54	526
50 mm.	42	309

[1]) Remark: This trawl was made of thin twine.

A. Trawls with 30 mm. meshes in the cod-end and 30, 40, and 50 mm. in the front part.
B. Trawls with 40 mm. meshes in the cod-end and 30 and 50 mm. meshes in the front part.
C. Trawls with 45 mm. meshes in the cod-end and 30, 45 and 50 mm. meshes in the front part.

Our computation has been made only for *Pleuronectes flesus*. The second species, *Pleuronectes limanda*, does not occur so universally nor so numerously. Besides, it would require additional discussion and comparison on account of the abnormal occurence of particularly numerous young year-classes.

Research on the influence of the front part of the trawl was based on the analysis both of industrial catches and of experimental catches made in 96 hauls; the data concerning the fish examined include 18521 measurements: all catches were made in the autumn months in 1928 in the same locality near Hel.

Taking into consideration all the above remarks and comparing the computations of undersized fish in proportion to the 1000 full sized fish in particular, we must admit that the front part plays a very important rôle in the escape of undersized fish and has a great significance for all modifications of industrial fishing gear planned to increase protective ability.

Thus we see, for example, that if we introduce larger meshes into the front part of the "destructive«" trawls they immediately bring about "protective" characteristics, and the quantity of undersized as related to the full sized fish become twice as small with the commercial size limit of 18 cm. and four times as small when the commercial size limit is 20 cm. The same process is to be observed in the activity of the trawl with 40 and 45 mm. meshes in the cod-end.

This would tend to prove the arguments which we might have put forth *a priori*, basing them on the principle of the probability of escape. Each mesh of the net through which a fish can possibly pass represents for it a chance of escape. Since the front part is composed of a much larger quantity of meshes the chances of escape from these parts ought to increase proportionally. It is true that some fish may be squeezed mechanically through the meshes of the cod-end. On the other hand, however, in case of more abundant catches the meshes in the cod-end may be quite blocked by larger specimens and then the chances of escape from the trawl become much smaller.

6. The influence of the lower part and the sides, as compared to that of the upper and middle parts.

It remains to be seen which parts of the front section of the trawl have anything to do with the escape of fish. Up to the present day the idea seems to be universally prevailing that the lower part of the trawl has nothing to do with the escape of the fish.

In order to elucidate this problem the experiments in 1928 were conducted by using alternately trawls which had either the whole lower net made of 24 mm. meshes, and the whole upper net of 45 mm. or *vice versa*. In another series of experiments the sides (i.e. $^1/_4$ of the whole circumference on each side) had 24 mm. meshes and the middle parts (i.e. $^1/_4$ of the circumference on the top and $^1/_4$ of the circumference on the bottom) had 45 mm. meshes.

The results obtained have been presented in part A of Table IV. The research was based on the measurements of the whole catch of 35 hauls, comprising altogether 5998 fishes of both species. Comparing the curves of the catch of all these trawls and the computation of the relation of undersized to the full sized fish, we do not find fundamental differences within a given species. This compels us to accept the conclusion that all parts of a trawl play more or less the same rôle in the escape of fish, and differences depend only on the species caught and the size of the fish.

In order to test this conclusion experimental catches were made in 1929 with the double trawl; the inner trawl had 45 mm. meshes, the cover — 24 mm.; the covering trawl had been sewn together lengthwise with the inner trawl in four places so that it was divided into four equal parts, one upper, one bottom and two side ones.

At first the catches were made on two hauls with an inner trawl with 50 mm. meshes: unfortunately this trawl was lost on the third haul. The results obtained in these two first experiments agree entirely with the later ones.

In part B of Table IV there is a rough computation of the results of these experiments comprising the measurements of 5387 fish caught in 7 hauls during September and October 1929.

Even a rough presentation of these numbers proves to us that the escape takes place in all directions and at very much the same rate. The fact that the lower part of the trawl is as important as the sides and the upper part is of special importance. There are deviations in this or that direction, which depend not only on the species and the size of fish caught but on the locality in which the catch has been made.

Part C of Table IV contains the results of the same experiments

Table IV. The importance of the bottom

A. The number of undersized fish held by

1. Influence of the bottom part:

The size of meshes in the bottom part of trawl	Commercial size 18 cm.		Commercial size 2	
	Flounder	Dab	Flounder	
I. 24 mm	259	1202	1291	3
II. 45 mm	236	1985	1049	5

B. The number of fish escaped from the 45 mm. tr

Size of fish in cm....	8	9	10	11	
Flounder (3386 fish measured on 7 hauls).					
Number of fish escaped through (total 3066):					
the upper part	1	40	113	159	1
the bottom part	5	88	140	248	1
side parts	..	8	100	230	2
Number of fish remained inside the trawl (320)	..	..	1	..	
Dab (2001 fish measured on 7 hauls).					
Number of fish escaped through (total 1445):					
the upper part	..	..	4	11	
the bottom part	4	14	32	53	
side parts	..	..	2	16	
Number of fish remained inside the trawl (556)	..	..	..	..	

C. The influence of the upper, bottom and side parts of the t

Size of fish in cm....	8		9		10		11		12		
A. Flounder:	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pi
The upper part	1	17	40	29	113	32	159	25	196	32	1
The bottom part	5	83	88	65	140	39	249	39	141	23	
The side parts	..	..	8	6	100	28	230	36	275	44	2
Inner trawl	..	..	..	..	1	1	..	..	6	1	
Total...	6	100	136	100	354	100	638	100	618	100	4

Size of fish in cm....	22	23	24	25	26
Inner trawl, pieces (100 %)	20	18	8	10	3

Size of fish in cm....	8		9		10		11		12		
B. Dab:	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pi
The upper part	..	..	..	..	4	20	11	19	38	20	
The bottom part	..	..	4	100	14	70	32	54	52	27	
The side parts	..	..	..	..	2	10	16	27	96	50	1
Inner trawl	..	..	..	..	..	..	..	..	5	3	
Total...	..	..	4	100	20	100	59	100	191	100	2

Size of fish in cm....	22	23	24	25	26
Inner trawl, pieces (100 %)	46	28	28	24	17

the trawl in the escape of undersized fish.
proportion to 1000 full sized fish caught.

2. Influence of the side part:

ze of meshes in the e part of trawl	Commercial size 18 cm.		Commercial size 20 cm.	
	Flounder	Dab	Flounder	Dab
m.....	143	3265	600	746
m.....	195	883	636	2676

he various parts of the covering trawl (25 mm.).

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
64	45	27	13	12	..	..	..	..	..	..	..	..	..	..
23	17	1	1	..	..	..	..	..	..	..	..	..	..	..
93	44	21	7	2	1	..	..	..	..	..	..	..	..	..
27	34	44	30	45	32	20	16	8	10	3	3	4	..	.
59	47	30	10	5	2	..	..	..	..	..	..	..	..	..
4	4	1	..	..	..	..	..	..	..	..	..	..	..	..
136	83	30	6	2	..	..	..	..	..	..	..	..	..	..
33	29	88	47	94	28	46	28	28	24	17	15	13	8	31

ping of unmeasured fish. (The trawl 45 mm. cover 25 mm.)

	15		16		17		18		19		20		21	
%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%
31	80	29	64	31	45	32	27	29	13	25	12	20	..	..
20	56	20	23	11	17	12	1	1	1	2	..	..	..	..
47	126	46	93	45	44	32	21	23	7	14	2	4	1	3
2	12	5	27	13	33	24	44	47	30	59	45	76	32	97
00	274	100	207	100	139	100	93	100	51	100	59	100	33	100

29	30	31	32	33	34	35
4	1	2	2	3	1	1

	15		16		17		18		19		20		21	
	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%	pieces	%
25	55	25	59	24	47	26	30	20	10	15	5	5	2	6
6	23	10	22	9	19	11	4	3	4	6	1	1	..	..
56	132	60	136	54	83	47	30	20	6	9	2	2	..	..
3	11	5	33	13	29	16	88	57	47	70	94	94	..	..
0	221	100	250	100	178	100	152	100	67	100	102	100	2	..

29	30	31	32	33	34	35
8	11	3	8	6	2	1

Table V. The detailed computation of fish escaped through different parts of th inner trawl in separate hauls.

A. The number of fish and ‰ — separately for undersized — > 17 cm. and full sized — < 18 cm.

Date	Trawl		Number of fish caught		Number of fish retained		Number of fish retained by								
							Inner trawl		Cover Trawl						
									upper part		bottom part		side parts		
			> 17 cm	< 18 cm	inside	cover	> 17 cm	< 18 cm	> 17 cm	< 18 cm	> 17 cm	< 18 cm	> 17 cm	< 18 cm	
Flounder:															
28.9.29	55 mm.	pieces	413	48	5	456	..	5	134	22	78	4	201	17	pieces
	with cover	‰	..	..	..	..	..	104	324	458	189	84	487	354	‰
	25 mm.														
31.9.29	—	pieces	523	40	9	554	1	8	114	13	249	8	159	11	pieces
		‰	..	..	..	..	2	200	218	325	476	200	304	275	‰
14.9.29	45 mm.	pieces	199	36	33	202	4	29	54	3	32	1	109	3	pieces
	with cover	‰	..	..	..	..	20	804	271	84	161	28	548	84	‰
	25 mm.														
14.9.29	—	pieces	131	23	20	134	7	13	11	3	27	2	86	5	pieces
		‰	..	..	..	..	54	565	84	131	206	86	656	217	‰
21.9.29	—	pieces	257	57	62	252	20	42	75	2	53	..	109	13	pieces
		‰	..	..	..	..	78	735	292	35	206	..	424	228	‰
25.9.29	—	pieces	263	23	39	247	21	18	78	3	43	..	121	2	pieces
		‰	..	..	..	..	80	782	297	131	163	..	460	87	‰
25.9.29	—	pieces	124	14	14	124	3	11	46	2	16	1	59	..	pieces
		‰	..	..	..	..	24	786	371	143	129	71	476	..	‰
16.10.29	—	pieces	810	80	77	813	20	57	362	17	26	3	402	3	pieces
		‰	..	..	..	..	25	713	447	213	32	37	496	37	‰
24.10.29	—	pieces	591	87	75	598	17	58	281	22	59	2	234	5	pieces
		‰	..	..	..	..	29	665	475	253	100	24	396	58	‰
Dab:															
28.8.29	55 mm.	pieces	308	31	4	335	..	4	157	13	75	3	76	11	pieces
	with cover	‰	..	..	..	..	..	130	510	419	243	97	247	354	‰
	25 mm.														
31.8.29	—	pieces	395	33	1	427	..	1	132	15	141	9	122	8	pieces
	45 mm.	‰	..	..	..	..	..	30	334	455	357	273	309	242	‰
14.9.29	with cover	pieces	244	150	156	237	22	134	74	7	32	1	116	8	pieces
	25 mm.	‰	..	..	..	..	90	893	303	47	131	7	476	53	‰
14.9.29		pieces	280	110	121	269	23	98	11	3	27	2	219	7	pieces
		‰	..	..	..	..	82	891	39	27	97	18	782	64	‰
21.9.29		pieces	184	49	52	181	12	40	64	3	53	..	55	6	pieces
		‰	..	..	..	..	65	816	348	61	288	..	299	123	‰
25.9.29	—	pieces	390	90	67	396	17	67	54	9	43	..	236	14	pieces
		‰	..	..	..	..	43	744	249	100	110	..	605	156	‰
25.9.29	—	pieces	100	31	34	97	7	27	24	1	16	1	53	2	pieces
		‰	..	..	..	..	70	871	240	32	100	32	530	65	‰
16.10.29	—	pieces	70	50	40	80	4	36	20	11	26	3	20	..	pieces
		‰	..	..	..	..	58	720	285	220	372	60	285	..	‰
24.10.29	—	pieces	160	102	86	174	4	84	50	15	59	2	47	1	pieces
		‰	..	..	..	..	25	823	312	147	369	20	294	10	‰

Size of fish in cm....	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	Total
1. The inner trawl 55 mm. cover 25 mm.																													
Flounder (991 fish measured on 2 hauls):																													
Escaped through the upp. part.	20	37	40	57	135	125	168	165	104	61	30	27	24	7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the bottom p.	57	182	155	41	125	137	72	105	48	42	21	3	6	6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the side parts	18	62	85	54	95	131	164	144	116	57	15	26	8	8	8	3	3	3	..	..	..	..	..	..	..	..	..	..	1000
Remained inside the inner trawl.	..	..	..	..	..	..	..	..	..	71	..	71	71	17	215	144	..	71	71	..	..	144	..	..	..	..	..	..	1000
Dab (776 fish measured on 2 hauls):																													
Escaped through the upp. part.	..	17	23	40	36	116	194	135	165	119	33	63	23	23	3	7	3	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the bottom p.	4	13	31	26	197	338	123	105	62	48	13	18	18	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the side parts	9	41	152	226	124	166	120	74	37	28	9	..	..	..	..	..	..	..	9	..	5	..	..	..	..	..	..	..	1000
Remained inside the inner trawl.	..	..	..	..	..	..	..	..	..	..	..	250	250	..	250	..	..	250	..	..	..	..	..	..	..	..	..	..	1000
2. The inner trawl 45 mm. cover 25 mm.																													
Flounder (3386 fish measured on 7 hauls):																													
Escaped through the upp. part.	1	42	118	166	204	124	94	83	67	47	28	14	13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the bottom p.	6	103	164	291	165	91	66	65	27	20	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the side parts.	..	6	80	184	220	168	107	101	74	35	17	5	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Remained inside the inner trawl.	..	..	3	..	19	19	19	37	84	106	138	94	141	100	63	50	25	..	31	9	9	14	3	6	6	9	3	3	1000
Dab (2001 fish measured on 7 hauls):																													
Escaped through the upp. part.	..	..	10	29	99	168	155	142	153	122	78	26	13	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the bottom p.	..	15	53	121	196	200	140	87	83	71	15	15	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Escaped through the side parts.	..	..	3	20	121	198	109	160	171	104	38	7	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1000
Remained inside the inner trawl.	..	..	..	..	9	7	13	20	59	52	158	85	170	50	83	50	50	43	31	27	23	14	20	5	14	11	4	2	1000

calculated in percentages for each size of fish. This computation shows more clearly how important the bottom part of the trawl is for saving immature fish, especially for sizes 8, 9, 10 cm.; flounders of these sizes escaped in the proportions 83 %, 65 % and 39 % through the bottom part; as regards dabs, even fishes of a larger size, 9, 10, 11 cm., escaped through the same part in the proportions 100 %, 70 % and 54 %.

In Table V we find the detailed records of each haul; the fishes are divided into two groups with reference to the commercial size 18 cm.: undersized and full sized; the results are computed for each group in proportion to 1000. We can observe that in all cases, without exception, we find the undersized fish escaping through the bottom part of the inner trawl; this part of the catch in some hauls is very considerable and consists mostly of the smallest specimens.

The above considerations, based on the results of experiments with trawls in Polish waters, authorise us to state that:—

1) The catch of undersized fish depends primarily on the size of mesh used, and a "savings mesh" could be established for each commercial size.
2) If a "savings mesh" is used, the chances of retaining or losing undersized fish depend on the number of meshes; therefore not only the cod-end but also the front part of the trawl is of great importance.
3) The undersized fish, try to escape through "savings meshes" not only in the sides of the trawl, but also in the upper and even in the bottom part, the last being especially important for the smallest fish.

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Iodine Content of American Marine Animals.

By

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We have previously determined the iodine contents of Norwegian fishes and fish products (6, 8) and also of several marine invertebrates in order to obtain a picture of the circulation of the iodine in the sea. We found it, however, to be of great importance to know the iodine content of the marine animals from other seas also in order to compare them with the figures for the iodine content in animals from the Norwegian seas. We have determined the iodine in specimens from Woods Hole, Mass., from La Jolla, Calif, and from the Seattle Fish Markets. Our thanks are due to the U. S. Bureau of Fisheries for collecting the samples from Woods Hole, Mass., and to Dr. VAUGHAN, Director of the Scripps Institute of Oceanography, La Jolla, who made it possible for one of us (G. L.) to secure samples from La Jolla during a short stay there. Dr. R. W. CLOUGH at the North-West Branch, National Canners Association assisted one of us (G. L.) in collecting samples from the Seattle Fish Markets, and placed the Laboratory of the National Canners Association, Seattle, Wash., at his disposal for weighing and preserving the samples. The preliminary report of our results for the species from the first two places were published in December 1928 (10).

Analytical method.

The method of TH. VON FELLENBERG (2) was used with slight modifications. The method as used by us is fully described (9, 12) and only a brief description of its chief points need be given here. For details we refer to the mentioned paper (12). 20 to 100 g. samples were weighed and heated on the water-bath with about $^1/_4$ to $^1/_2$ of their weight of potassium hydroxide and some water, until a homogeneous solution was obtained. For samples containing much fat some alcohol may be added to facilitate the saponification.

If the samples to be analysed are preserved in alcohol (this was the case with all the samples here examined), the alcohol is removed by decantation, and a separate determination of the iodine content is made in the solid sample and the alcoholic extract. In such cases the solid sample is dissolved with potassium hydroxide as described, and the alcoholic extract is heated on the water-bath with potassium hydroxide and water until complete saponification of the fats is effected.

Of the solutions thus obtained an aliquot part corresponding to about 1—2 g. of the original sample (more for samples poor in iodine) is transferred to a flat iron dish (10 cm. diameter). 2 ccm. of an iodine-free, saturated aqueous solution of potash is added[1]), and the solution is evaporated on the water-bath to dryness. To accelerate the evaporation the dish may be heated carefully on the sand-bath. The iron dish is now heated on a gas burner, or better, on an electric furnace, until the incineration of all organic substance is completed. The dish must not be heated higher than to a dull redness. In most cases complete incineration cannot be obtained unless the carbonised sample is cooled, mixed with water, and heated to a dull redness again. This procedure might be repeated once or twice until the sample is of a pure white or, on account of the presence of ferric oxide, light brown colour. More or less greyish colours indicate that the ignition is insufficient and should be repeated.

After complete incineration the residue is extracted with alcohol (90 %) in the iron dish. The salts must be thoroughly mixed with alcohol by grinding with an agate pestle, and the alcoholic solution containing the iodine is removed by decantation. This procedure must be repeated twice. Lunde and Wülfert do not now extract directly in the iron dish. They dissolve the residue of ignition in a little water, add more potash solution and transfer to a micro-apparatus for the extraction of liquids as described by Laquer (5). The alcoholic extract is collected in a flat, gold, or gold-platinum (10 % Pt.) dish (6 cm. diameter). A few drops of potash solution and some water are added. The liquor is evaporated to dryness and the residue heated very carefully over a gas burner. Special care has to be taken that the dish does not become glowing during the procedure. The residue must be of a pure white colour, and is now extracted with alcohol again as described for the extraction in the iron dish. The alcoholic extracts are gathered in a

[1]) According to v. Fellenberg (2) the potash solution is made iodine-free by shaking up 10 times with ethyl-alcohol in the separating funnel. Lunde and Wülfert recommend the use of an extraction apparatus for liquids as described by Friederichs, for the continuous extraction of the iodine-containing salts with alcohol.

gold-platinum, or platinum dish, some water is added, the solution is evaporated on the water bath and the residue again carefully heated without the addition of potash. The residue is dissolved in a little water and transferred to an Erlenmeyer glass flask (50 ccm.) and titrated.

The titration is performed according to WINKLER's method (17). The method is thoroughly described by LUNDE, CLOSS and BÖE (12). We may also refer to an important paper on the determination of small quantities of iodine recently published by REITH (14).

Experiments.

The specimens from Woods Hole, Mass., were collected June 1928 and preserved in alcohol (96 %). The investigations were carried out December 1928, and the iodine determined separately in the solid part of the sample and in the alcoholic extract. In all cases from 60—90 % of the total iodine was found in alcohol except in one sample with only 13 % in alcohol. This sample was a very fat specimen (Menhaden). In this case, however, the alcohol added had only extracted a very small part of the fish fat. The results of the analyses are presented in the following table 1.

Table 1. Iodine Content of Teleosts from Woods Hole, Mass.

Nr.		Caught	Dry residue in %	Iodine in mg pr. kg	
				fresh substance	water free substance
1	Menhaden (*Brevoortia tyrannus*)	June 20, 1928	51.2	0.46	0.90
2	Pollack (*Pollachius virens*)	July 14, 1928	28.3	0.43	1.52
3	Mackerel (*Scomber scombrus*) ..	June 22, 1928	44.0	0.12	0.27
4	Haddock (*Melanogrammus aeglefinus*)	July 14, 1928	28.0	6.74	24.07
5	Cusk (*Brosmius brosme*)	July 14, 1928	35.0	0.17	0.49
6	Winter flounder (*Pseudopleuronectes americanus*).....	June 22, 1928	28.0	0.53	1.89
7	Cod (*Gadus callarias*).....	July 14, 1928	28.0	0.79	2.82

The samples from La Jolla, Calif., were collected in June 1928 and analysed in December 1928. As for the samples from Woods Hole, Mass., the iodine was determined separately in the solid part and in the alcoholic extract. In all cases from 75—85 % of the iodine was found in the alcoholic extract. The results of the analyses are given in the following table 2.

Table 2. Iodine Content of Teleosts from La Jolla, Calif.

Nr.		Caught	Total weight of animal in g.	Dry residue in %	Iodine in mg pr. kg	
					fresh substance	water-free substance
8	Mackerel (*Scomber japonicus*) Muscle and skin	June 26 1928	42	(44.0)	0.099	(0.225)
9	*Atharinapsis californiensis*, muscle and skin	—	30	24.5	0.318	1.298
10	Kelp bass (*Paralabrax clathratus*)	—	110	21.26	0.040	0.188
11	Sheepshead (*Pimelometabon bulchar*)	—	279	18.69	0.068	0.364
12	Black perch (*Emtriatocoa jacksoni*)	—	101	19.75	0.059	0.299

Table 3. Iodine Content of Teleosts from the Seattle Fish Markets. (July 11th, 1928).

Nr.		Iodine in mg pr. kg	
		fresh flesh	fresh skin
13[1]	Halibut (*Hippoglossus vulgaris*)	0.094	..
14	Sole (*Psettichthys melanosticus*)	0.163	..
15	Sole (*Parophrys vetulus*)	0.103	..
16	Viviparous (blue) perch (*Taeniotica lateralis*)	0.063	..
17	Silvery viviparous perch (*Damalichthys argyrosomus*)	0.178	..
18	Red cod (*Sebastodes ruberrimus*)	0.163	..
19	Bass (Large dark *Sebastodes caurinus*)	0.040	..
20	Bass (Small rough headed *Sebastodes caurinus*)	0.146	..
21	Bass (*Sebastodes melanops*)	1.03	0.307
22	Small bass (Smooth headed *Sebastodes melanops*)	0.093	..
23	Ling cod (*Ophidion elongatus*)	0.332	0.316
24	Starry flounder (*Platichthys stellatus*)	0.183	0.303
25	Black cod (*Anaplopoma fimbria*)	0.350	0.186
26	King salmon (*Oncorhynchus tschawytscha*)	0.139	1.80
27[2]	Sockeye salmon (*Oncorhynchus nerka*)	0.805	..
28	Hump salmon (*Oncorhynchus gorbuscha*)	0.397	1.61
29[2]	Chum salmon (*Oncorhynchus keta*)	0.470	..
30	Silver salmon, Coho (*Oncorhynchus kisutch*)	0.112	..
31[2]	Steelhead trout (*Salmo gairdneri*)	1.15	..

[1]) Caught in the Gulf of Alaska.

[2]) No. 27, 29 and 31 samples taken from the head of fish.

The species from the Seattle Fish Markets were collected in July 1928, preserved in alcohol and analysed June—July 1929. For some of the specimens samples of the skin also were investigated. The results of the analyses are found in table 3 (page 219).

We also determined the iodine content of some edible shell-fishes from the Seattle Fish Markets and of starfish and spiny lobster from La Jolla. The results of these investigations are presented in the following table 4.

Table 4. Iodine Content of Invertebrates.

Nr.	Species	Total weight in g.	Dry residue in %	Iodine in mg pr. kg	
				fresh substance	water-free substance
	Seattle Fish Markets July 11th, 1928:				
32	Eastern Oyster (*Ostrea virginiana*)	..	18.9	0.31	1.64
33	Western Oyster (*Ostrea lurida*)	..	10.7	0.34	3.20
34	Little-neck (*Paphia staminea*).	..	10.5	0.22	2.18
35	Scallop (*Pectin*)				
	Gonads	..	..	0.73	..
	Internal organs (without gonads)	..	16.9	1.79	10.59
	Abductor muscles	..	..	0.18	..
	La Jolla. June 26th, 1928:				
36	Star-fish (*Asterias forrei*)	122	..	0.46	..
37	Spiny lobster (*Palinurus interruptus*), muscle	289	24.5	0.82	3.33

For *Asterias forrei* and the shell of *Palinurus interruptus* a sample was extracted with alcohol. The alcohol-insoluble portion was treated with hydrochloric acid, and the iodine determined in these extracts and in the residue. The results are quoted in table 5.

Table 5.

Extract	Asterias forrei		Palinurus, shell	
	Iodine		Iodine	
	in mg pr. kg	in %	in mg pr. kg	in %
Alcohol	0.19	42.3	0.32	2.6
Hydrochloric acid	0.26	56.0	11.94	97.3
Insoluble in HCl	0.01	1.8	0.02	0.1
Sum	0.46	..	12.27	..

Comparison of our results with those of other investigators.

The iodine content of some American sea foods was determined by Tressler and Wells (15). These authors used a somewhat different method of iodine determination. Jarvis, Clough and Clark (3) determined the iodine content of Pacific coast salmon, and recently Jarvis (4) published the results of iodine determination in Pacific coast sea foods.

Table 6. Results of Iodine Determinations in American Teleosts and Invertebrates compared with those of other Investigators.

Nr.	Species	Iodine in mg pr. kg. fresh substance			
		Our Figures	Tressler, Wells	Jarvis, Clough, Clark	Jarvis
2	*Pollachius virens*	0.43	0.12	..	..
3	*Scomber scombrus*	0.12	0.14	..	..
4	*Melanogrammus aeglefinus*	6.74	0.29	..	..
6	*Pseudopleuronectes americanus*	0.53	0.18	..	..
7	*Gadus callarias*	0.79	0.24	..	..
8	*Scomber japonicus*	0.099	..	..	0.231
13	*Hippoglossus vulgaris*	0.094	0.25	..	0.304
17	*Damalichthys argyrosomus*	0.178	..	..	0.176
21	*Sebastodes melanops*	1.03	..	..	0.178
23	*Ophidion elongatus*	0.332	..	..	0.138
24	*Plathichthys stellatus*	0.183	..	..	0.233
25	*Anaplopoma fimbria*	0.350	..	..	0.547
26	*Oncorhynchus tschawytscha*	0.139	..	0.119—0.798	0.364
27	*Oncorhynchus nerka*	0.805	..	0.132—0.519	0.405
28	*Oncorhynchus gorbuscha*	0.397	..	0.186—0.569	0.264
29	*Oncorhynchus keta*	0.470	..	0.132—0.420	0.242
30	*Oncorhynchus kisutch*	0.112	..	..	0.206
31	*Salmo gairdneri*	1.15	..	..	0.377
32	*Ostrea virginiana*	0.310	1.16	..	..
33	*Ostrea lurida*	0.342	..	..	0.935
34	*Paphia staminea*	0.224	..	..	0.833
37	*Palinurus interruptus*	0.816	—	..	0.322

In Table 6 we have compared our figures with those of the abovementioned authors. The table contains our figures only as far as the same species have been the subject of investigation by other authors. It appears from the table that the figures of Jarvis and of Jarvis, Clough and Clark are of about the same order as ours. The figures of Tressler and Wells are for some species considerably lower than ours. Especially for no. 4 (Haddock) our figure is about 25 times as high as the figure of Tressler and Wells. Our studies of Norwegian

fishes, however, have shown that there is an evident difference in the iodine content at different times of the year, and that the iodine content apparently becomes very high in spring during and after the flowering of plankton in the upper layers of the sea. All the material examined by us was collected in June—July 1928. The authors cited do not mention the time when their material was collected. We are of the opinion that the differences between our figures and the others may be explained by fishing ground and time. Our detailed investigations on the influences of these factors on the iodine content in teleosts are to be published later. The mentioned factors can hardly explain the difference between our figure and the figure found by TRESSLER and WELLS for the species no. 4 (Haddock). It is shown below, however, that the iodine content of this species is about the same as that found for the same fish caught off the Norwegian coast. At this point we desire merely to call attention to this fact. We find it too early to draw further conclusions.

Table 7.

	Iodine in mg pr. kg fresh flesh	
	American species	Corresponding Norwegian species
Haddock:		
Melanogrammus aeglefinus	6.74	..
Gadus aeglefinus	..	6.23
Cod:		
Gadus callarias, syn. *G. morrhua*	0.79	5.17
Pollock:		
Pollachius virens	0.43	..
Gadus virens	..	3.11
Cusk:		
Brosmius brosme	0.17	3.60
Mackerel:		
Scomber scombrus	0.12	0.45
Halibut:		
Hippoglossus hippoglossus, syn. *H. vulgaris*	0.094	1.19
Flounder:		
Pseudopleuronectes americanus	0.53	..
Platichthys stellatus	0.183	..
Pleuronectes platessa	..	0.71
Herring:		
Clupea pallasii	0.214[1])	..
Clupea harengus	..	0.17

[1]) JARVIS.

Discussion.

A comparison of our results as published in this paper with our previous investigations on marine animals off the Norwegian coast (7, 8) shows that there is an evident difference in the iodine content. In table 7 (p. 222) we have compared the results of our investigations on American teleosts with the corresponding Norwegian species previously examined by us. For nearly all of the species the figures for the Norwegian forms are seen to be considerably higher. For haddock only the figures are of about the same order. It must be remembered, however, that American authors found the iodine content of haddock to be much smaller. Menhaden has not previously been the subject of investigations. WELLS (16), however, determined the iodine content of Menhaden fish meal. He found 1.08 mg. I. pr. kg. water-free menhaden fish meal. This figure is in good agreement with our figure for menhaden flesh, 0.90 mg. I. pr. kg. water-free substance. JARVIS, CLOUGH and CLARK (3) determined the iodine content of Atlantic salmon from Gaspe Bay (Eastern Canada) to 0.227 mg. I. pr. kg. moist substance, a figure which is in good agreement with our figure for *Salmo salar* caught on the west coast of Norway, May 1928, 0.26 mg. I. pr. kg. fresh substance (8).

We have previously called attention to the high iodine content of some species of Norwegian fish (7, 8). In another paper it will be shown that this fact is due to special nutrition and living conditions of the marine animals.

We also have compared our results for *Asterias forrei* from La Jolla with the corresponding Norwegian species *Asterias glacialis* (Table 8).

Table 8.

Extract	Iodine in mg pr. kg fresh substance	
	Asterias forrei	Asterias glacialis
Alcohol	0.19	0.52
Soluble in potassium carbonate	¥	0.17
Soluble in hydrochloric acid	0.26	0.53
Residue	0.01	0.07
Sum...	0.46	1.29

The iodine content of the Norwegian species is higher. The distribution of the iodine in the different fractions is about the same in both cases.

The shell of Norwegian crustaceans was previously investigated by us (1, 7). We compare these results with the figures for *Palinurus interruptus* from La Jolla (table 9).

Table 9.

Extract	Iodine in mg pr. kg fresh substance		
	Palinurus interruptus, shell	Homarus vulgaris, shell	Pandalus borealis, shell
Alcohol	0.32	3.17	1.07
Hydrochloric acid	11.94	5.87	⋮
Residue	0.02	18.39	4.75
Sum...	12.28	27.43	5.82

In the Norwegian species there is a relatively higher amount of the iodine insoluble in alcohol. On the other hand a greater amount of the alcohol-insoluble part of the Palinurus shell is soluble in hydrochloric acid.

For some species the iodine content of the skin from the same sample was determined. For 2 species only, King salmon and Hump salmon

Table 10. The Iodine Content of Flesh and Skin.

	Iodine in mg pr. kg fresh substance			
	American species		Corresponding Norwegian species	
	flesh	skin	flesh	skin
Flounder:				
Platichthys stellatus	0.183	0.303	..	..
Pleuronectes platessa	..	..	0.870	0.706
Bass resp. Red-Fish:				
Sebastodes melanops	1.03	0.307	..	..
Sebastes marinus	..	..	1.41	0.796
Salmon resp. Sea trout:				
Oncorhynchus tschawytscha	0.139	1.80	..	..
Oncorhynchus gorbuscha	0.397	1.61	..	..
Salmo salar	..	..	0.350[1] / 0.170[2]	0.849
Salmo eriox	..	..	0.565[1] / 0.170[2]	0.405

[1]) curdy. [2]) lean.

(no. 26 and 28) the iodine content of the skin was decidedly higher. These two species are very fat fishes. For Norwegian fishes we also found a higher iodine content of the skin than of the lean parts of the flesh of some fat species, salmon (*Salmo salar*) and sea trout (*Salmo eriox*). In table 10 (p. 224) we have compared our figures for the iodine content of the skin of some Norwegian species (1) with our results for corresponding American species (table 10).

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Correspondence.

1.

We have pleasure in publishing the following note sent by Dr. BIGELOW, *announcing the establishment of the new Woods Hole Oceanographic Institution.* EDITOR.

The Woods Hole Oceanographic Institution.

It is gratifying to report that the study of the present status of oceanography made by the Committee of the National Academy on that subject, and their recommendations[1]) have borne fruit in the incorporation of a new establishment for the study of the sea, the Woods Hole Oceanographic Institution. And it is still more encouraging to students in sea science that the Rockefeller Foundation has appropriated for the new Institution funds sufficient to assure it an adequate building program, and sufficient operating income.

The purpose of the new institution, as its name implies, is to carry on and to encourage the study of the sea in the broadest sense. Like the Marine Biological Laboratory, it is an independent organization, but similarly assured of informal association with other educational and research institutions through the personnel of its Trustees. The initial board is as follows: Dr. THOMAS BARBOUR, Dr. HENRY B. BIGELOW (Director), Dr. WILLIAM BOWIE, Dr. E. G. CONKLIN, Mr. NEWCOMB CARLTON, Dr. BENJAMIN M. DUGGAR, Dr. FRANK R. LILLIE (President), Dr. JOHN C. MERRIAM, Mr. SEWARD D. PROSSER, Mr. LAWRASON RIGGS, Jr. (Treasurer), Mr. ELIHU ROOT, Jr., Dr. HARLOW SHAPLEY, Dr. T. WAYLAND VAUGHAN. And the by-laws provide for an increase in the number of Trustees up to twenty-four.

The choice of Woods Hole as the site for the headquarters of the new institution was reached only after a careful consideration of other possible situations along the Atlantic coast of North America. The final decision was based on the combined advantage of close proximity to two world-famed laboratories of Marine Biology on the one hand, and, on the other, on the exceptional opportunity for illustrative investigations that is offered by the neighboring waters.

The first of these inducements needs no explanation. The second depends in part upon the ease with which the transition from inshore to offshore waters can be reached from Woods Hole, on the abruptness

[1]) Science, Vol. LXXI, pp. 84—89.

of that transition, and on proximity to the continental slope. At the same time the Gulf of Maine close at hand, with its tributaries, offers a more promising field for intensive investigations into the interaction between the physical-chemical and the biologic aspects of oceanography than any other sector of comparable extent along the coast of America. This follows from the fact that deep troughs, freely open to the ocean, enclosed sinks, a varied coast line, a wide range of depth, and offshore banks supporting some of the most productive of sea fisheries can all be reached and within a few hours sail from Woods Hole, while the transition from regions of extreme turbulence to waters more stable can be followed within short distances. The thermal diversity (regional, bathymetric and seasonal), is also wide, with temperature ranging within a few miles of Woods Hole, and at different seasons, from below the freezing point of fresh water to values almost tropical. A wide variation in the fertility of the local waters for pelagic plants is reflected by variation in the mass productions of the latter, while the faunal associations (including the planktonic) are equally diverse and abundant.

In short there is hardly an oceanographic problem but can be hopefully attacked close to Woods Hole, unless primarily associated either with tropical shallows, with arctic ice or with mid-oceanic conditions. And the northeastern coast of the United States with neighboring parts of Canada is the most convenient headquarters for studies in the last two of these fields combined, because of nearness on the one hand to the ice laden Labrador Current (chief discharge of Arctic waters into the Atlantic) and on the other to the open Atlantic basin, with Bermuda in the offing as the possible site of a future substation.

The preceding remarks introduce one of the most important features of the institution's program, namely, that it expects to own and operate a sea-going ship, of moderate size, with convenient living quarters, capable of extended voyages and equipped to carry on investigations at all depths in the various fields of sea science. And this is the more desirable because no other American marine laboratory independent of governmental control is at present in condition to do this. To make the most of such facilities, it is planned to keep the laboratory open with resident staff, and the ship in commission the year round.

Plans for the laboratory building, docks, etc., are now being prepared, and the Institution hopes to open its doors by the summer of 1931. Before that time the Trustees expect to announce in detail what facilities can be offered, and what initial program of research is planned, based on the general purpose of offering every opportunity (compatible with work on ship-board) for participation by visiting oceanographers,

whether from America or from abroad. This implies field-investigations in a variety of subjects, for which the offing of Woods Hole is favorable, for the reason just stated. The most essential activities of the institution may be expected to center around the work at sea. In this connection it must, accordingly, be recognized that the technical requirement of oceanography (necessity for obtaining the raw data for the major problems at sea) will confine the projects that can be undertaken at any one time to those that can be provided for simultaneously by the station's fleet. Consequently the activities, not only of the staff, but likewise of many of the visitors must be coordinated parts of a joint program. At the same time the Laboratory purposes to offer every hospitality to individual workers who may elect to attack, independently, any problems the data for which can be obtained from the pier or from small boats.

At present few opportunities are open for the student of oceanography to gain experience in the technique of his subject, and the first-hand intimacy with the sea that he requires as a background for his detailed studies. The Institution therefore expects to offer to university students instruction in oceanographic methods, by participation both in the cruises, and in the general work of the Laboratory.

To carry out this part of the program, as well as to make the facilities available to qualified investigators, friendly and continuing relations with universities are obviously essential. Equally essential will be a constant endeavor to encourage the coordination of effort between various scientific institutions of different countries, that is especially needed in Oceanography, where the area to be covered is so vast, and where so many fields of science intertwine.

2.

We are informed that the Bureau of Applied Ichthyology (Leningrad) has been included with the Institute of Fisheries (Moscow) in the newly organized "Institute of Fishery Industries and Scientific Exploration", of the Lenin Academy of Agricultural Sciences U. S. S. R., as its Leningrad and Moscow Divisions.

Professor KNIPOVITCH has been nominated Director of the Institute.

The address of the Leningrad Division and of the Board of the Institute is: Leningrad, Herzen Street, 38. EDITOR.

Reviews.

Bjørn Helland-Hansen. Nybygningen for Det Geofysiske Institut. Særtrykk av Bergens Museums Årsberetning, 1928—1929.

I had hardly sat down to write this little article, when the news came in that Nansen was dead! The last time I saw him was in Bergen, two years ago, when the Geophysical Institute was opened; the first time was more than forty years ago, in the same little town, when he was a young naturalist in the Museum, — when he was dreaming of exploration and adventure. Even his dreams were not so great and wide as what he afterwards achieved.

The town of Bergen has not a little of that brave, unselfish adventurous spirit which Nansen possessed in a supreme degree; even the old Universities of Scandinavia, vigourous as is their intellectual life, do no more for physical and natural science, nor for letters and the arts, than this little merchant-town.

Professor Helland-Hansen's pamphlet is a short account, illustrated by plans and figures, of the Institute over which he presides. It is a beautiful building. Its windows overlook the fjord and its tower looks out to sea. It has been built, equipped and endowed by Bergen men, without their asking the State for a penny. On the ground floor are the chemical and part of the physical laboratories, these latter under Prof. Helland-Hansen's special charge. The work which goes on here is largely hydrodynamical, and is part and parcel of that immense contribution to the dynamical theory of wind and water currents, of ocean circulation in general, which we owe to Walfrid Ekman, Sverdrup, Hesselberg, Helland-Hansen himself, and most of all to Professor V. Bjerknes. An experimental tank 15 metres long, built of reinforced concrete, is placed in the basement, and is equipped with all sorts of apparatus for the study of currents, waves, vortices and the like. A disused railway tunnel happens to run below the building, at a depth of about 50 ft., and for a length of seventy or eighty yards: it is a happy chance for the Institute. The tunnel has a constant temperature, all the year round, of about 10° C., or just a very little above the mean annual temperature of Bergen; it forms a curious and unusual annex to the laboratory, very perfectly adapted by its quiet atmosphere and even temperature for various aerodynamical and other experiments.

The main upper floor contains laboratories for Dr. H. U. Sverdrup and for Dr. Krogness. The latter is engaged in a magnetic survey of

Norway, with the help of Prof. Störmer of Oslo, Professor Saeland and Prof. Lars Vegard, all of them men of international repute as students of terrestrial magnetism; Prof. Störmer's researches on the aurora are especially well known. In connection with this and other magnetic work a considerable part of the laboratory, no less than five rooms and two more in the cellarage, have been completely enclosed in a wire network, hidden from view in the plaster of the walls, and forming a very complete and extensive "Faraday cage".

The "Armauer Hansen", a little yawl of 58 tons burden, with a 40 h.p. motor to work the winches and drive the vessel in case of need, has her moorings just below the laboratory, in the fjord. Helland-Hansen and his friends think nothing of a voyage to the Azores in this little boat, and have been to Rockall and Madeira and all over the north-eastern Atlantic, again and again.

The three-storied tower of the Institute is given over to the meteorologists, under Dr. Jacob Bjerknes, the third of his scientific dynasty. Jacob Bjerknes has much of the spirit of travel and adventure which Helland-Hansen (not to speak of the great Nansen himself) possesses. I once happened to cross the Atlantic in company with him and his father; and I am sure there were not many hours out of each twenty-four when the son, a young man then, was not at work on the bridge or in the rigging.

In the tower, as the plans in Dr. Helland-Hansen's pamphlet show, there is an elaborate telegraphic and wireless installation, as well as the usual meteorological instruments and workrooms. It is interesting to find that the Norwegian meteorologists depend much on actual observation of the sky for their forecasting work. We do such work in South Kensington or in Kingsway, and no-one doubts that we do it there extremely well; but the Bergen weather-experts want an opener sky, and like to keep the weather itself before their eyes. They want to watch the clouds driving home over the Atlantic, and their Institute has its high tower that they may watch from. It is an open secret that even our own Meteorological Office has had something to learn in the way of forecasting, from "Jack" Bjerknes's friendly visits.

The older members of the International Council have not forgotten the days when Fridtjof Nansen and Helland-Hansen came constantly to its meetings, and took a great part in its deliberations. When we in Scotland began our work, we had much to learn from the Bergen hydrographers. I remember translating, the important paper in which Sandström and Helland-Hansen first epitomised V. Bjerknes's hydrodynamical researches; and Helland-Hansen himself came over to take charge of our first hydrographic observations, on our first cruise to Faeroe.

The little pamphlet in which Professor Helland-Hansen tells the story of his Institute and its work, and all the rest of what we have seen and heard of the Bergen school, make a delightful impression; one can hardly read the story without wanting to go and see for oneself, and few indeed are they who would not learn much by doing so.

D'Arcy W. Thompson.

Th. Hesselberg. Ein neuer Ausdruck für den Austauschkoeffizienten. Annalen der Hydrographie usw. LVII Jahrg. (1929). Heft X. Berlin 1929.

The word "Austauschkoeffizient" which can probably best be given in English by "coefficient of exchange" was introduced into meteorological and hydrographical literature by W. Schmidt (1917). It can be defined as the amount of some attribute of the fluid (e.g. heat, salt, plankton, momentum etc.) which is carried in unit time through a unit surface in the fluid by certain turbulent movements, when the decrease of the characteristic quality (e.g. temperature, salinity, amount of plankton per kilo, velocity etc.) given to the fluid by the attribute is one unit per unit length in the direction vertical to the surface in question.

If, for example, we take the salinity of the seawater as the quality to be considered in this connection and let Q be the amount of salt carried through a unit area, S the salinity of the water, t the time and z the distance in the direction perpendicular to the area in question, we have the coefficient of exchange η determined by the equation:—

$$\frac{dQ}{dt} = -\eta \cdot \frac{dS}{dz}$$

which is analogous to the equations used in dealing with conduction of heat and with diffusion.

Th. Hesselberg has formerly published various investigations of the coefficient of exchange for the atmosphere and in the present article now gives a new expression for the coefficient of exchange applicable to the conditions both in the atmosphere and in the sea.

The following summary of the article should, however, be taken only with reference to conditions in the sea.

The actual movements of the water particles may be resolved into 1) the resultant motion, which is common to all the particles considered, and 2) the turbulent motion.

The turbulent motions of the water particles which account for the exchange of water from one side of a surface in the sea to the other, and *vice versa*, may be resolved into components parallel to an area A of the surface considered and components perpendicular to it. The exchange of water through the area is due only to the last components.

These components perpendicular to the area A are supposed to be of a certain nature, and, if the coefficient of exchange in the space considered is to be regarded as a constant, Hesselberg's assumptions may, I think, be formulated as follows:—

1) The conditions are stationary in the space considered.
2) The sum of the components, perpendicular to the area A, of the velocities, of the particles in a volume, two of whose dimensions are given by the area A, is equal to zero for every interval of time.
3) A water particle will retain its velocity of turbulent motion unaltered through a fixed interval of time $\frac{P}{2}$. After the lapse of that time the

velocity is suddenly altered and the particle will keep its new velocity through the time $\frac{P}{2}$, when it will again be altered, and so on.

4) When the turbulent velocity of a water particle is altered, the particle will acquire the qualities of the water at that point at which the alteration occurred, and it will then keep those qualities (e.g. the velocity parallel to the area A, the temperature, the salinity, etc.) through the time $\frac{P}{2}$.

5) The points at which the velocities are altered for the different particles are equally distributed in the space considered.

6) The frequency of the above-mentioned velocity components perpendicular to the area A is given by Maxwell's Law at any time over the space considered.

TH. HESSELBERG then expresses the coefficient of exchange with regard to temperature, salinity and the momentum parallel to the area A by

$$\eta = \varrho \cdot \frac{P}{2} \cdot \int_0^\infty F \cdot u^2 \cdot du \qquad (1)$$

ϱ being the density of the sea-water, $\frac{P}{2}$ the interval of time during which a particle keeps its turbulent velocity unaltered, F the frequency according to Maxwell's Law and u the velocity component normal to the area A.

The expression (1) is also given by HESSELBERG in the following form:—

$$\eta = \frac{1}{4} \cdot \varrho \cdot P \cdot \bar{u}^2 \qquad (2)$$

where $\bar{u}^2$ indicates the mean of the squares of the velocity components.

Taking an expression from the theory of errors, $\bar{u}^2$ can be denominated as the square of the standard deviation of the velocity components.

The expression found by HESSELBERG is of special interest in that, under certain definite assumptions, it gives an insight into the mechanics of the exchange of water.

It seems, however, that the assumptions adopted are more restrictive than necessary and it may be doubted if they are in accordance with fact.

It follows directly from the assumptions, as HESSELBERG shows, that the coefficient of exchange should be the same both for momentum parallel to the area A and, for example, for salinity.

Some time ago the reviewer found that the "mixing coefficient", which differs from the coefficient of exchange only by the factor ϱ in the vertical direction, is different for the horizontal momentum and for salinity, and has since confirmed this.

Instead of the assumptions 3), 4) and 6) it would perhaps be more in accordance with the facts to make the supposition that:—

7) The frequency of the paths z of the elements of volume of water, which are carried away with unaltered "conservative" qualities (temperature,

salinity etc.) by the turbulent movements from a definite unit volume in a definite direction and in an arbitrary unit of time, is given by the law of normal distribution (MAXWELL's expression).

The coefficient of exchange through an area A, when z is vertical to A, can then be written:—

$$\eta = \frac{1}{2}\varrho \cdot \overline{z}^2 \qquad (3)$$

which signifies in words half the product of the specific gravity and the "square of the standard deviation of the paths" referred to the unit of time used.

According to supposition 7), it should be possible for a water particle in motion to alter its velocity parallel to the area A without altering, for example, its salinity. Then the paths of a particle with unaltered qualities would be different for momentum parallel to the area A and for salinity. The momentum can be said to have a looser connection with the water than, for instance, the salt and can be partly transferred from sheet to sheet independently of the transfer of the water particles themselves.

Then, for momentum, a supposition analogous to 7) should be made, that:—

The frequency of the paths z for different uniform fractions of the momentum parallel to the area A, which is found in a certain volume and carried away by the turbulent movements in a direction perpendicular to A in an arbitrary unit of time, is given by the law of normal distribution.

Then the coefficient of exchange for momentum is also expressed by formula (3), with the special value of $\overline{z}^2$ referring to the momentum.

Besides the above-mentioned principles, the article discusses the exchange of energy and various other questions. The study of the coefficient of exchange is undoubtedly more advanced for the atmosphere than for the sea, but, even if it should not be possible to admit all the results obtained, it will undoubtedly be of great interest to study them by planning investigations at sea, which is the only way in which we are able to decide upon the reality of the theoretical deliberations leading to formula (1) or to formula (3). J. P. JACOBSEN.

J. P. JACOBSEN. Eine graphische Methode zur Bestimmung des Vermischungskoeffizienten im Meere. Gerlands Beiträge zur Geophysik. Bd. XVI, Heft 4. Leipzig 1927.

In this paper Dr. JACOBSEN attacks a problem of great importance in hydrographical research, namely, how to obtain a measure of the extent to which, under oceanic conditions, intermixture takes place between superimposed, homogeneous water-masses possessing different physical characteristics. Incidentally it is claimed that the method expounded by the author has a wider application than the determination merely of a quantity termed "the mixing coefficient".

Being largely mathematical, the paper is appropriately opened with a short summary.

The graphical basis of the method which, theoretically, is founded upon the assumption that the laws relating to the diffusion of liquids are also applicable to the phenomenon of "mixing", is not new, being simply a curve drawn to the rectangular co-ordinates, temperature and salinity. Depths are marked on the curve itself at the appropriate points. A false observation is exposed by plotting the same along with the others belonging to the same station, provided always that observations are sufficiently numerous.

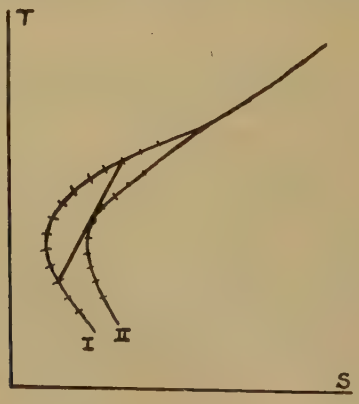
Such a curve, called a "T.S.-Diagram", representing the routine observations of a hydrographic station, may, in the absence of any current, afford information relative to the homogeneity or otherwise of the various water-layers, for, obviously, identical temperature and salinity readings, although pertaining to several depths, will be represented on the figure by a single point. A cluster of depth-marks on the curve, therefore, indicates homogeneity in the water-layers between the limiting depths of the group.

A portion of the curve for a particular station may be found to run, between two clusters of depth-marks, nearly in a straight line with depth-marks more or less well spaced along it. In the absence of current, intermixture between the two homogeneous water-masses is thus indicated and the degree of such at any of the intermediate depths for which observations are available is the ratio in which the depth-mark divides the specified portion of the curve.

The introduction to the co-ordinate diagram of the corresponding curves of equal density enables a qualitative estimate to be made concerning the vertical equilibrium at the station under examination.

Comparison of conditions at a number of stations, or at the same station at various times, may be effected by tracing the appropriate curves on transparent paper over the "key" sheet bearing the axes and curves of reference. By this means characteristically similar water-masses may be approximately defined in relation to their geographical orientation.

Two series of observations taken at the same station, but at different times, may be found to yield curves varying slightly between certain depths, as in the diagram, indicating vertical mixing between the depths in question. The "coefficient of mixing" is to be determined graphically



by drawing a tangent to the inner curve at the point of greatest curvature, thus cutting off an arc from the outer curve. The depth difference represented by this arc gives the value s in the formula:—

$$\mu t = \frac{1}{8} \cdot s^2$$

where μ is "the mixing coefficient" and t signifies time. J. B. T.

J. P. Jacobsen. Contribution to the Hydrography of the North Atlantic. The "Dana"-Expedition 1921—22, with 25 Tables and 63 Figures in the Text. The Danish "Dana"-Expedition 1920—22 in the North Atlantic and the Gulf of Panama, Oceanographical Reports edited by the "Dana"-Committee. Nr. 3. Copenhagen—London 1929.

Auf der 1921—1922 unter der Leitung von Johs. Schmidt ausgeführten "Dana"-Expedition in den Nordatlantik wurden ausser den biologischen Hauptaufgaben auch hydrographische Beobachtungen (t, S, O_2) ausgeführt und zwar von Johs. Olsen und N. C. Andersen; die Bearbeitung des gesammelten Materials erfolgte durch J. P. Jacobsen, die Beobachtungstabellen selbst sind kürzlich von Johs. Schmidt in Nr. 1 der oben genannten Veröffentlichungsreihe mitgeteilt worden.

Zur Verschaffung eines hydrographischen Überblickes wurden die insgesamt 66 Stationen zu 10 Schnitten vereinigt und diese diskutiert. Vier Schnitte queren grössere Teile des offenen Ozeans und zwar von der Biscaya nach Haiti, von der Sargasso See nach Kap Norfolk, von der Strasse von Gibraltar nach den Kap Verden und von dort nach Cayenne. Auf ihnen tritt im Nordosten der Einfluss des Mittelmeerwassers und ausserhalb dessen Einflussbereiches der des antarktischen Zwischenstromes klar hervor. Die Tiefen unterhalb von 3000 m werden vom Wasser des nordatlantischen Tiefenstromes eingenommen, auf dem von den Kapverdischen Inseln nach Cayenne reichenden Schnitt ist dieser bereits durch den antarktischen Bodenstrom unterlagert. Die übrigen sechs Schnitte verlaufen im Bereiche des Antillen- und Florida-Stromes und zwar zwei im Caribischen Meere und im Atlantik parallel den Westindischen Inseln, die anderen zwischen Yukatan und Cuba, vom Florida Riff nach Cuba, von Florida nach der Bahama Bank und von San Salvador in Richtung nach dem Sargasso Meer, so dass hier wertvolles Material für ein genaueres Studium der Entwickelung des Golfstromes beschafft worden ist. Besonders bemerkenswert ist der Gegensatz in den hydrographischen Verhältnissen innerhalb und ausserhalb des westindischen Inselkranzes. Temperatur und Salzgehalt des Wassers im Caribischen Meere entspricht unterhalb von etwa 2000 m dem in etwa 1500 m Tiefe im benachbarten Ozean befindlichen Wasser, verändert nur durch die adiabatische Temperaturzunahme. Der Temperaturgegensatz dieser beiden Gebiete ist daher recht erheblich; z. B. wurde in 4000 m Tiefe südöstlich von Puertorico 4.22° und in geringem Abstand nördlich dieser Insel 2.44° festgestellt. Bemerkt sei, dass an dieser letzteren, am Rande des Puertoricograbens befindlichen Position zwischen 4000 und 5000 m adiabatische Temperaturzunahme von 2.44° auf 2.55° vorzuliegen scheint.

Für die Diskussion im einzelnen wurden Temperatur-Salzgehalts-Diagramme benutzt in wohl grösserem Umfange und eingehender als bisher bei der Erörterung hydrographischen Materials geschehen ist. Jacobsen fasst das den Ozean erfüllende Wasser auf als zusammengesetzt aus homogenen Wasserarten und Mischwasser aus diesen. Als homogene Wasserarten sieht er die folgenden sechs an:

E = Äquatorialstromwasser (Oberflächenwasser in Nähe des Äquators $t = 27.4°$, $S = 34.9\ ^0/_{00}$).
A = Golfstromwasser (Antillen- und Floridastrom von 0—100 m Tiefe, $t = 24°$, $S = 36.3\ ^0/_{00}$).
C = Wasser der Sargassosee in 100 m Tiefe ($t = 22°$, $S = 37.0\ ^0/_{00}$).
B = Nordatlantischer Tiefenstrom ($t = 2.5°$, $S = 34.9\ ^0/_{00}$).
M = Mittelmeerwasser ($t = 9.5°$, $S = 35.8\ ^0/_{00}$).
S = Antarktischer Zwischenstrom ($t = 5.4°$, $S = 34.6\ ^0/_{00}$).

Zur Ableitung von deren Temperatur und Salzgehalt wurde ausser dem "Dana"-Material auch das von anderen Expeditionen in Betracht kommende herangezogen. Im TS-Diagramm erscheinen diese 6 Wasserarten als Punkte und das Mischwasser von je zweien von diesen als die betreffenden beiden Punkte verbindende Gerade. Für dieses Mischwasser wurden die abgekürzten Bezeichnungen CS-Wasser oder BS-Wasser usw. gewählt. Nach Schaffung dieser Grundlagen wurden alle im Nordatlantik zwischen dem Äquator und 60° n. Br. bisher gewonnenen Serienwerte in TS-Diagramme eingetragen und aus dem Verlaufe der TS-Kurven und deren Lage zu den theoretisch möglichen Mischwasserkurven festgestellt, welcher Ursprung für das Wasser der verschiedenen Tiefen anzunehmen ist. Es ergab sich, dass für den Nordatlantik bis 60° n. Br. 24 Typen von TS-Kurven abzuleiten und danach 24 hydrographisch einheitliche Regionen von naturgemäss stark wechselnder Grösse zu unterscheiden sind. Wie der vom Verfasser durchgeführte Versuch zeigt, gestattet diese Methode eine sehr ins einzelne gehende und anschauliche Betrachtung der Herkunft der verschiedenen Wasserarten und erleichtert vielfach Einzelheiten aufzudecken, die bei Anwendung allein der Schnitte kaum erkannt werden würden, so dass sie eine wertvolle Ergänzung und Vertiefung der bisher üblichen Bearbeitungsmethoden bildet. Nützlich erweisen sich die TS-Diagramme u. a. bei der Verfolgung des Mittelmeerwassers im nordöstlichen Atlantik, dessen Einfluss westwärts bis etwa 40° w. Lg. und im Süden bis zu den Kapverdeschen Inseln verfolgt werden konnte, ebenso auch bei der Untersuchung der Ausbreitung des antarktischen Zwischenstromes.

Bruno Schulz.

Erik Martens. Hydrographical Investigations during the "Michael Sars"-Expedition 1924. Cons. Perm. Int. pour l'Explor. de la Mer. Rapp. et Proc.-Verb. Vol. LVI, Copenhague 1929.

Der Verfasser bespricht das ihm von Professor Hjort in aufgearbeitetem Zustand übergebene ozeanographische Material, dass auf der Reise des "Michael Sars" von Norwegen über Island nach der Davisstrasse

gesammelt worden ist und Beobachtungen von Temperatur, Salzgehalt, Sauerstoff und Wasserstoffionenkonzentration enthält. Das Material wird in 3 Abschnitte gegliedert: das Gebiet zwischen Norwegen und den Faröern mit 2 ozeanographischen Schnitten, das Gebiet zwischen Island und Cape Farvel mit einem Schnitt, das Gebiet westlich von Grönland (Davisstrasse) mit 2 Querschnitten und einem Längsschnitt. Eine genauere Karte würde die Orientierung erleichtern.

Der erste Schnitt (Station 5—13) beginnt auf dem norwegischen Schelf in ca. 64° N. und endet nördlich der Faröer; der zweite etwas südlich gelegene (Station 67—74) läuft vom norwegischen Schelf in ca. 60° N. direkt auf die Faröer zu. Beide Profile, die in enger Anlehnung an die Ergebnisse von Nansen und Helland-Hansen in "the Norwegian Sea" diskutiert werden, zeigen gut das in den oberen Schichten nordwärts setzende atlantische Wasser, in das sich östlich der Faröer kühles Wasser, das einen letzten Ausläufer des Ostislandpolarstromes bildet, mit geringen Salzgehalts- und p_H-Werten einschiebt. Darunter liegt ab ca. 600 m Bodenwasser mit 34,90 ‰ und Temperaturen von weniger als 1°.

Der Schnitt zwischen Reykjavik und Cape Farvel enthält auf dieser über 500 Sm. langen Strecke nur 5 Stationen (27—31), von denen zwei nur bis 50 bezw. 300 m herabreichen. Ihm kommt daher nicht die Bedeutung zu, die ihm der Verfasser vielleicht geben möchte, wenn er meint, dass der Schnitt durch eines der Verbindungstore zwischen Nordmeer und Atlantischen Ozean ginge, zumal da das Profil im spitzen Winkel zu den Stromrichtungen verläuft; immerhin kann man das Auskeilen des atlantischen Wassers von NE. nach SW. von 1000 m Mächtigkeit bei Station 27 bis auf 200 m Mächtigkeit bei Station 30 gut erkennen.

Etwas reichlicher ist das Material in der Davisstrasse. Es gestattet einen Schnitt in NE.—SW.-Richtung über den Westgrönlandschelf zwischen 65 und 63° N., einen Querschnitt zwischen 65 und 67° N. und eine Längsprofil (Station 58 bis 46) zu zeichnen. Die Profile, die wohl vorwiegend nach biologischen Gesichtspunkten angelegt wurden, sind für ozeanographische Zwecke nicht gerade günstig, da sie auch hier wieder die vorherrschende Stromrichtung nicht rechtwinklig kreuzen und ausserdem auf Zickzack-Kursen verlaufen (Station 41, 42, 43 werden sowohl für einen Längsschnitt als auch für einen Querschnitt verwendet).

Man erkennt aus den Schnitten, dass über dem Grönlandschelf Küsten- bezw., Bank-Wasser von 33 ‰ und 4—5° liegt, unter das sich in der Tiefe nach Norden setzendes Wasser von 34,8 ‰ Salzgehalt und 3—4° C. schiebt. Dieser im Vergleich zur Umgebung hohe Betrag von Salzgehalt und Temperatur ist auf die Einwirkung atlantischen Wassers zurückzuführen.

Auf der Westseite setzt Wasser polarer Herkunft mit 31—33 ‰ und Temperaturen von 0—1° nach Süden. Es schiebt sich keilförmig zwischen das grönländische Küstenwasser und das atlantische Wasser in der Tiefe. Die zum Schluss durchgeführte Berechnung der Stromgeschwindigkeit in der Davisstrasse nach Bjerknes gibt, unter der Voraussetzung, dass sich das Polarwasser mit ca. 30 cm/sec nach Süden bewegt, ein Bild von der Verteilung der Geschwindigkeiten in der Davisstrasse. Ob diese Annahme richtig ist, mag dahingestellt bleiben; auf jeden Fall wäre es

wohl besser gewesen, bei der Berechnung von der "Nullschicht" zwischen dem nord- und südwärts setzenden Wasser auszugehen." G. B.

Erik Martens. Hydrographical Investigations in the Norwegian Sea off Möre 1925—1928. Cons. Perm. Int. pour l'Explor. de la Mer. Rapp. et Proc.-Verb. Vol. LVI, Copenhague 1929.

Der Verfasser behandelt in vorliegender Arbeit ozeanographische Schnitte, die durch Professor Hjort im Frühjahr und Sommer der Jahre 1925—1928 in 14-tägigen Abständen über dem Schelf von Storeggen vor der Mündung des Romsdalsfjord gemacht wurden. Sie erstrecken sich bis zu 50 bezw. 200 Sm. Abstand vom Lande in nordwestlicher Richtung von Björnsund. Als Ergänzung treten im August 1927 Strommessungen hinzu, die im Verein mit der schwedischen hydrographisch-biologischen Kommission angestellt wurden. Diese Strommessungen wurden mit einem von O. Pettersson angegebenen photographisch registrierendem Instrument ausgeführt. Der Strommesser wurde nicht vom verankerten Schiff ausgebracht, sondern an einem System von Bojen gehalten. Ob das Instrument bei dieser Art von Ausbringung sehr viel ruhiger hängt als vom Schiff aus, mag dahingestellt bleiben; sicher ist jedenfalls, dass man die Bewegung der Bojen unter Wasser nicht kennt, während man die Bewegung des Schiffes durch Ablesen des Kompasses bezw. Messen des Neigungswinkels der Ankertrosse u. s. w. immerhin einigermassen verfolgen kann. Die Strommesser selbst scheinen zufriedenstellend gearbeitet zu haben. Als Mangel wurde lediglich der Umstand empfunden, dass man die Filme nicht sofort nach den Messungen entwickeln konnte.

Um die kurzfristigen Veränderungen der hydrographischen Verhältnisse über dem Schelf während der Zeit der Strommessungen verfolgen zu können, wurden in der Zeit vom 8.—14., bezw. 18. August eine Reihe von sternförmigen um die Strommessungsstation verteilten ozeanographischen Stationen erledigt. Von diesen wurde die Hauptstation viermal wiederholt.

Die zusammenhängende Betrachtung für alle diese Stationen ergibt für die Dauer der Beobachtungszeit ähnliche Verhältnisse in Bezug auf die Schichtung der Wassermassen, während Salzgehalt und Temperatur im einzelnen natürlich Schwankungen unterworfen sind. Die Strommessungen ergeben einen resultierenden Strom nach NE. Ein Vergleich des gemessenen Stromes mit dem aus Temperatur und Salzgehalt nach Bjerknes berechneten, ergibt keine befriedigende Übereinstimmung; der Verfasser führt dies auf Mängel in der Berechnungsmethode zurück.

Ein zweiter Abschnitt wird der Beschreibung der eingangs erwähnten Schnitte über dem Storeggen-Schelfe gewidmet, von denen 19 in der Zeit von März 1926 bis August 1928 bis 50 Meilen Abstand von der Küste und vier, die sich bis zu 200 Meilen Abstand von der Küste erstrecken, veröffentlicht sind. Die Schnitte zeigen die aus den früheren Arbeiten von Helland-Hansen und Nansen bekannten ozeanographischen Verhältnisse: so, dass Küstenwasser von 32—34 $^0/_{00}$ über dem eigentlichen Schelfe und das atlantische Wasser von über 35 $^0/_{00}$ über dem Schelfrande bezw. am Kontinentalabhang. Diese Wasserkörper ändern je nach Jahreszeit und Wetterlage ihre Einflusssphäre.

Die Veränderungen während der einzelnen Jahre und Monate werden in einem letzten Abschnitt an Hand von Diagrammen für verschiedene Stationen besprochen. Es wäre zu wünschen, dass die Untersuchungen weitergeführt werden, damit man später, was jetzt noch nicht möglich ist, ein genaueres Bild über die hydrographischen Verhältnisse und ihren Wechsel im Laufe der Jahreszeiten und Jahre erhält. G. B.

Sir F. Stupart, J. Patterson, and H. G. Smith. Ocean Surface-Water Temperatures - Methods of Measuring and Preliminary Results. Bull. Nat. Research Council. No. 68. Washington, D. C., 1929. pp. 76—88.

Some ten years ago the Canadian Meteorological Service took steps to organise the collection of surface-water temperatures at sea, to provide material for the study of the weather in North America. In common with others who have made similar attempts, they encountered the difficulty that the usual methods employed on board ship for observing the water temperature do not, as a rule, supply data as accurate as desirable for scientific purposes. These obstacles need not be mentioned here in detail, as the subject has been extensively treated by Dr. C. F. Brooks (and others), two of whose papers have already been noticed in this Journal[1]). Efforts to obtain more reliable observations led to the adoption of methods which are novel in their application to this class of work, and which shew the authors to have enjoyed an enviable freedom from precedent. They state that the first essential seemed to be that the thermometer should be constantly maintained at sea temperature: this could best be done by immersion in a well. The most convenient position for such a well would be in the condenser intake pipe, close to the ship's side, in the engine room. Though fully aware of the possibility of differences between the temperature of the uppermost 6 or 8 inches of water and that of the water 20 or 30 feet below, this position was finally adopted. This matter also has been studied by Dr. Brooks, who found justification for the use of measurements at condenser intake level as "surface" observations; it seems to be the authors' opinion, however, that the point needs some further attention.

Tests were made with two types of instrument, — the resistance-thermometer and the distance-thermograph. The former type, which was the first tried, did not give full satisfaction, as it was difficult to keep the instruments in order under the conditions of use. One such instrument was placed in an insulated box against the ship's side in the engine room and was compared with another fitted in the condenser intake pipe. There was evidence, however, that the one against the ship's side was affected by the temperature of the engine room.

The second type, the distance-thermograph, was, in spite of certain initial disadvantages, so much superior to the other type that it became the one permanently employed. The disadvantage referred to was the shortness of the life of the steel bulb, the copper plating with which it was coated being insufficient to prevent destruction of the bulb by electro-

[1]) Journ. du Conseil, III, 3, 1928, pp. 385—8, and IV, 2, 1929, pp. 236—8.

lytic action. This trouble was eventually overcome by fitting the bulb into a copper well, screwed into the condenser intake pipe and suitably packed.

The instrument finally chosen was of the mercury-in-steel type, with a wall-type recorder, which was placed so that the capillary used was about 10 to 15 feet in length. The record could be read to 0.2° F. (ca. 0.1° C.), and the range was from 30° to 90° F. (ca. —1° to 32° C.). In most cases weekly charts are used, but daily ones are substituted when the temperature fluctuations are likely to be large or sudden. It is not stated what methods are employed to check the instruments, and the accuracy of the records obtained is not discussed.

Instruments of this type have been installed during the past 5 years or so in various ships of the Canadian Service in both the Pacific and Atlantic Oceans. A considerable material has already been collected in the Pacific, but the Atlantic observations on the route from Montreal to the West Indies, — designed to trace variations in the boundary of the Gulf Stream, — are yet few.

After the description of instruments, the paper consists of a study of the data so far obtained, especially in regard to their relation with North American climatic conditions, — a subject rather outside the province of this Journal. The brief, but most interesting, discussion of variations in ocean temperature as cause or effect of similar variations in the atmosphere must nevertheless be referred to. J. R. L.

H. Thorade. Gezeitenuntersuchungen in der Deutschen Bucht der Nordsee. Nach Beobachtungen des Vermessungsschiffes "Panther" im Juni 1924. (Aus dem Archiv der Deutschen Seewarte, 46. Band, Nr. 3. 1928.)

Im Jahre 1924 wurde von der Deutschen Seewarte eine Untersuchung über die Gezeiten der Sylter Gewässer (A. d. Arch. d. D. Seew., 41. B. Nr. 2) als erster Teil einer grösseren geplanten Arbeit zur Erforschung der Gezeiten der Nordsee herausgegeben. Die vorliegende Arbeit bildet den zweiten Teil dieser Untersuchung. Es wird über Strommessungen an Bord des Vermessungsschiffes "Panther" während der Zeit 12. Juni—1. Juli 1924 berichtet. Die Messungen wurden teils für methodische Untersuchungen zur Strommessung, teils für örtliche Untersuchungen der Gezeiten ausgeführt. In die erste Gruppe gehören Untersuchungen zum Vergleich der Strommesser von Ekman-Merz und von Jacobsen und zur Prüfung ihrer Zuverlässigkeit, sowie Untersuchungen über die Störung der Strombeobachtungen durch das Schiff. Aus den Ergebnissen dieser Untersuchungen sei Folgendes hervorgehoben: Bei dem Strommesser von Ekman-Merz waren die Geschwindigkeitsangaben einwandfrei, aber die Richtungsangaben waren durch die Deviation der Kompassnadel infolge der Eisenteile des Schiffes beeinflusst. Es zeigte sich, dass sogar in 30 m Tiefe beim "Panther" (Kompositschiff aus Eisen und Holz) Deviationen von über 20° vorkamen. Bei dem Strommesser von Jacobsen waren die Richtungsangaben zuverlässig aber die Geschwindigkeitsangaben nicht genau genug. Bei den folgenden Messungen wurde deshalb die Richtung mit einem Libellenstrommesser von Jacobsen und die Geschwindigkeit mit einem

Propellerstrommesser von Ekman-Merz gemessen. Der Verfasser findet, dass von den älteren Strommessungen, die mit diesem Instrumente ausgeführt worden sind, nur die Geschwindigkeitsangaben benutzt werden können.

Durch die Wahl der Stationen, auf welchen Strommessungen ausgeführt wurden, wurde die Einwirkung einzelner geographischer Faktoren auf die Gezeitenerscheinungen studiert. Ferner wurden durch gleichzeitiges Messen auf dem "Panther" und auf einem näher der Küste ankernden Kutter die Unterschiede der Strömungen draussen im Meere und unter Land untersucht. Um den Unterschied zwischen Spring- und Nipptiden zu studieren, wurden Messungen annähernd an demselben Orte um Spring- und Nippzeit ausgeführt. Die Messungen wurden auf 6 verschiedenen Stationen in der Deutschen Bucht ausgeführt. Gleichzeitig wurden an Bord der Feuerschiffe "Norderney" und "Ausseneider" Strommessungen vorgenommen.

Ausserdem wurden auf dem "Panther" noch Temperatur- und Salzgehaltsbeobachtungen ausgeführt, sowie Lotungen, um die Gezeitenbewegungen im Wasserstande festzustellen. Die Lotungen wurden alle 10 Minuten wiederholt und zwar an drei verschiedenen Stellen an Bord, um die Einwirkung der Schwankungen des Schiffes zu eliminieren. Trotz dieses grossen Kraftaufwandes und der vorteilhaften Tiefenumstände und Bodenbeschaffenheit, zeigen die Resultate nach Ansicht des Verfassers, dass der Erfolg dieses Verfahrens fraglich ist, und dass die Verwendung selbsttätig aufzeichnender Instrumente zu erstreben ist.

Die Strommessungsergebnisse wurden in Nord- und Ostkomponenten zerlegt und nach Vielfachen der Mondgeschwindigkeit harmonisch analysiert sowie die Lage und Grösse der Stromellipsen berechnet. Auf Grund dieser Ergebnisse und unter Verwendung der obenerwähnten ergänzenden Beobachtungen werden die Gezeitenströme auf den untersuchten Stationen ausführlich besprochen. Graphische Darstellungen kommen in grossem Umfang zur Anwendung, was den Darlegungen eine besondere Anschaulichkeit verleiht. Die Tragweite der Schlüsse, die aus den Beobachtungsergebnissen gezogen werden, wird aber oft durch die Kürze der Beobachtungsdauer (15—40 Stunden) beschränkt. Die Wasserstands- und die meteorologischen Beobachtungen zeigen zwar, dass keine grossen Abweichungen von den mittleren Verhältnissen zu erwarten waren, aber in vielen Fällen ist doch ein grösseres Beobachtungsmaterial nötig, ehe die Erscheinungen endgültig dargelegt werden können.

Der Verfasser gibt ferner eine kurze theoretische Darstellung der Gezeitenströme, um die aus den Beobachtungen sich ergebenden Tatsachen qualitativ zu erklären. Der Begriff "Nullstrom" wird eingeführt, d.h. der Strom, der aus den vorhandenen Wasserstandsgradienten und gezeiterzeugenden Kräften unter Einwirkung der Erdumdrehung ohne Reibung entstehen würde. Die Einwirkung der Reibung auf den Nullstrom wird studiert. Der Verfasser berichtet zum Schluss über einige Versuche, den Wert des Reibungskoeffizienten zu ermitteln. Er findet u. a., dass dieser nicht nur von der gleichzeitigen Geschwindigkeitsverteilung abhängt, sondern im Vergleich zu den Veränderungen von dieser mehr oder weniger verspätet ist.

Die Bearbeitungen sind mit grosser Sorgfalt ausgeführt, und die Resultate enthalten manches, was für die Kenntnis der Gezeitenerscheinungen von Bedeutung ist. Man wird mit grösstem Interesse die Fortsetzung dieser Untersuchungen erwarten. S. E. Stenij.

K. Demel. Température des eaux côtières polonaises de la Baltique en 1926—28. "Kosmos", Journal de la Soc. Polonaise des Naturalistes. Vol. 54. Lwow, 1929. pp. 17, diagrammes 5. (En polonais avec un résumé en français).

La nôte contient les résultats des observations de température faites à un point fixe dans la Baltique, près de Hel (54°36′ N. 18°47′5 E.), tous les cinq jours dans les profondeurs de 0, 10, 20, 30, et 40 m pendant la période 1926—1928. L'auteur distingue deux périodes; une estivale à stratification thermique normale (Mai—Août), et une hivernale (Novembre-Février) à stratification inverse. Les périodes transitionelles sont moins bien marquées. M. S.

F. S. Russell and C. M. Yonge. The Seas. Our Knowledge of Life in the Seas and how it is gained. $11^1/_2 \times 15^1/_2$ cms. Cloth. pp. I—XIII and 1—379. 384 illustrations, of which 167 are coloured. Bibliography. Index. London and New York. 1928.

The authors of this attractive book have performed a remarkable feat. They have produced in what is almost a pocket edition a book whose scope is greater than that of the "Depths of the Ocean"; and given us a simply written survey of the whole field of Oceanography (with nearly 400 illustrations!) for the modest price of twelve shillings and sixpence. Many of the coloured figures have accuracy and artistic merit. Amongst these we may bestow great praise on those of planktonic and other organisms and the seascapes of Plates 1 and 102. A few, which appear to be made from stained photographs, do not reach the same standard.

The style throughout has the easy lucidity which we have learned to associate with the popular and other work of the authors. There is no doubt that this book would form the best available introduction to the subject, for anyone ignorant of oceanography. It is evident that the authors did not intend it to be more than a popular exposition of facts well known, for example, to readers of this journal. This book should be in the library of every boys' school in the maritime countries, and it will also make a strong appeal to the growing body of laymen who are interested in science. The expert, also, who happens to be comparatively ignorant of any particular branch of the science dealt with in the book, could not do better than read Russell and Yonge's straightforward account of the subject. We may, therefore, usefully make a list of the titles of the sixteen chapters:— General Introduction, The Sea Shore, The Sea Bottom, Swimming Animals, Drifting Life, Boring Life, Coral Reefs, Colour and Phosphorescence, Feeding of Marine Animals, Sea Water, Ocean Seasons, Methods of Oceanographical Research, The Sea Fisheries, The Shellfish Industry, Fishery Research, Products from the Sea. M. G.

B. Schulz und A. Wulff. Hydrographie und Oberflächenplankton des westlichen Barentsmeeres im Sommer 1927. Berichte der deutschen Wiss. Komm. f. Meeresforschung. N. F., Bd. IV. Heft 5. Berlin, 1929.

Data regarding the temperature, salinity, dissolved oxygen, hydrogen ion concentration, transparency and colour of the sea collected by the "Poseidon" during the summer of 1927 are tabulated and their distribution in the western part of the Barents Sea discussed and illustrated with diagrams and sections by Dr. Bruno Schulz. Five lines of stations running North (true) to beyond latitude 76° N. roughly equidistant and starting between Tromsö and the Sem Islands were worked. The middle line of stations (along the meridian 30° E.) was worked twice, early in August and again at the end of the month. At three positions in the open ocean, observations were made throughout a day and night, showing changes in the temperature and salinity, most marked in midwater layers, and having a 12 hours periodicity.

Dr. Alfred Wulff in the same publication (C. Ergebnisse der Untersuchung des Oberflächenplanktons) investigates the surface microplankton taken in August and September 1927, and here there is much that is of interest. In his former work (1926) on similar lines in connexion with the Barents Sea plankton collected by the "Zieten" this investigation was begun, and it is now taken up in greater detail, the more exact hydrographical data of the present voyage in the "Poseidon" being available. The most important part of this research is the critical work on the distribution of the tintinnids which seem to show distinctly that their characters are affected by their environment, and a variety of forms in a single species are described from the Barents Sea with its many sided and every changing conditions. These tintinnids have all been accurately measured and curves of their distribution given, with hydrographical data, besides elaborate diagrammatic drawings of the various forms. Two species of Favella are predominant, *Favella edentata* and *Favella denticulata*. The first is a small species, which is the principal form in the southern part of the Atlantic stream and especially in the Murman stream, the last has a small form var. *typica*, which comes from the East and inhabits the coastal waters, mixing in places with *F. edentata*. Larger forms of *F. denticulata* inhabit the mixed waters further from the coast and many of them have been separated into definite varieties, each occupying a special area.

A comparison with viscosity curves shows that there is a certain definite distribution, the stumpy and thicker forms living near the coast in the region of greater viscosity, the longer and thinner forms being found more in the open where the viscosity is less. This last relation also naturally depends upon temperature.

Other plankton organisms are also investigated, including peridinians, diatoms and flagellates. Amongst the peridinians *Ceratium longipes* and *C. arcticum* come from waters of different origins, *C. arcticum* from the East, *C. longipes* from the West and North. Peridinium is important, *P. depressum* and *P. ovatum* are abundant in the coastal waters but many other species depend on the currents both from East and West. Diatoms may occur in numbers both near the coast and in the outer waters, their mass development depending on hydrographical conditions. Certain species

of Chaetoceros are of special interest (*Ch. criophilum* and its form *volans*, *Ch. boreale*), in some cases intermediate forms between two species being observed. Rhizosolenia, especially *Rh. styliformis* and *Rh. semispina*, was also important. Of other groups, *Globigerina bulloides* is an Atlantic immigrant and *Halosphaera viridis* comes from the West, being wafted in masses between Faroe and Shetland into the Norwegian Sea, but, judging from researches into its life history, it probably breeds in the Barents Sea.

The whole of this investigation is very suggestive and is an important contribution to the knowledge of the minute life in these regions.

M. V. L. and H. W. H.

Ralph C. Lewis. The Food Habits of the California Sardine in Relation to the Seasonal Distribution of Microplankton. Bull. Scripps Inst. of Oceanogr., La Jolla, California. Technical Series. Vol. 2, No. 3. Berkeley, California. 1929.

Sardinia coerulia, the California Sardine, is readily obtainable throughout the year and is used by Mr. Lewis for his researches into the correlation of fish food with the distribution of microplankton. The California Sardine is a plankton feeder and its chief food consists of diatoms, dinoflagellates, copepods and other small crustacea, with an occasional fish.

Whenever possible surface plankton samples were taken where the fishes were caught and at the same time, the number of organisms in the samples being estimated as well as those from the stomachs of the fishes. The results show that the quality and quantity of the food varies with the season and depends on the amount and character of the prevailing microplankton. If diatoms be predominant, they form the chief food, if dinoflagellates or copepods, these are chiefly eaten. On one occasion only in winter some of the pilchards in a catch had the stomach full of *Euphausia pacifica*. This crustacean is known to frequent depths between 200 and 400 metres in the daytime, probably coming up nearer the surface at night. Copepods form a large part of the food at almost any time of year. Dinoflagellates occur in considerable numbers generally at the same time or rather later than the diatoms. In winter few diatoms and dinoflagellates were taken in February, but more in March, and only a few copepods. In spring diatoms and dinoflagellates were predominant with a general decrease in June, copepods abundant. In summer there were few diatoms until September, and a fair number of dinoflagellates, except in August; whilst copepods were fairly abundant. In autumn, when fewer samples were available, diatoms were abundant until November when their numbers decreased substantially, dinoflagellates in less numbers in the plankton than in the stomachs of the fishes, copepods fairly abundant.

In all these cases the numbers in the stomachs of the fishes almost always corresponded with the numbers in the plankton samples, and it seems a likely conclusion that the fishes go to those places where there is most food; also that the seasonal distribution of the microplankton can be correlated with the abundance of fishes which feed upon it. Temperature fluctuation apparently affects the presence of sardines indirectly, a low temperature being associated with the favourable growth of diatoms.

In February when there were fewer sardines, supplementary studies were made on some of the other plankton feeding fishes with similar results.

M. V. L.

J. Wołoszynska. Dinoflagellatae from the Polish coast of the Baltic and from the swamps near the mouth of the river Piasnica. Archives d'Hydrobiol. et d'Ichtyol. T. III, Warszawa, 1929, pp. 125, pl. 14 and figs. 4. (Polish with large abstract in German.)

The authoress gives a very careful, systematic review of 62 species from the Baltic (among them one new genus and five new species) and discusses their geographical distribution. Special chapters of the work are devoted to the comparison of the Dinoflagellates from the Baltic with the forms from Spitzbergen and Greenland, from the Arctic Ocean, from the Gulf of Kiel and from the coastal waters of Finland. These comparisons serve as a basis for the discussion of the historical development of the distribution of Dinoflagellates in the Baltic. The plates chiefly illustrate newly described and rare species.

M. S.

E. Percival. A Report on the Fauna of the Estuaries of the River Tamar and the River Lynher. — Journal of the Marine Biological Association of the United Kingdom. N. S. Vol. XVI, No. 1. Plymouth 1929, p. 81—108 (with 1 Figure in the Text and 1 Chart).

Arbeiten, welche sich mit der Ökologie eines Brackwassergebietes beschäftigen, sind noch immer ziemlich selten und ihre Erscheinung ist daher freudig zu begrüssen. Ganz besonders, wenn sich der Verfasser nicht auf eine einzige Zone z. B. das eigentliche Brackwasser (mesohalinikum) beschränkt, sondern das ganze Mischgebiet — die oligo-, meso- und polyhalinen Zonen — als ein Ganzes betrachtet und auf Grund vergleichender Untersuchungen zu einer Erkenntnis der in den verschiedenen Zonen prävalierenden Existenzbedingungen und der dadurch bedingten biocoenotischen Unterschiede zu gelangen strebt.

Die Arbeit Percivals beschäftigt sich vorwiegend mit der Fauna und Flora des Tamarflusses, der die Grenze zwischen Cornwall und Devon bildet und unweit Plymouth in den Englischen Kanal ausmündet. Nebenbei enthält sie auch einige Angaben über den Lynher, einen Nebenfluss des Tamars. Das Untersuchungsgebiet im Tamar erstreckt sich von Plymouth Sound etwa 19 Meilen (30.5 km) stromaufwärts bis Weir Head. Im oberen Teil sind die Ufer felsig, im mittleren und unteren Teil vorwiegend schlammig, an einigen Stellen findet man groben Kies. Über die Beschaffenheit der Gesteine fehlen leider Angaben; über die des Schlammes teilt der Verfasser nur mit, dass der Schlamm hauptsächlich grau bis schwarz ist. Für seine Konsistenz gebraucht er einen etwas sonderbaren Massstab; diese schwankt nämlich: "from tough clay-like material into which a man of 168 lbs. may sink to a depth of about 6 inches, to thin "slurry" into which he may sink to a depth of about 3 feet. The greater part of the area examined has mud into which he may sink to a depth of from 9 to 18 inches"!

Da das Gefälle steil ist, erreichen die Strömungsgeschwindigkeiten

offenbar hohe Werte. Auch hierüber fehlen genauere Angaben; nur teilt der Verfasser mit, dass das Hochwasser bei Calstock, 13 Meilen oberhalb Plymouth, nur etwa 23 Minuten später als hier sich einstellt, was einer mittleren Geschwindigkeit von etwa 1.5 m/sec. entspricht. Es leuchtet ein, dass auch der Salzgehalt an einer und derselben Stelle stark und verhältnissmässig schnell wechselt. Simultanbeobachtungen für die ganze Strecke konnten nicht angestellt werden; der Verfasser suchte sich dadurch zu helfen, dass er die Wasserproben an seinen Stationen möglichst bei derselben Gezeitenphase schöpfte.

Die Angaben über den Salzgehalt beziehen sich wahrscheinlich alle auf das Oberflächenwasser, — der Verfasser gibt dies nicht ausdrücklich an — weil gelegentlich auch über den Einfluss des Regenfalls auf den Salzgehalt die Rede ist.

Über die Salinität des Wassers am Boden, die ja bekanntlich im Gezeitenareal der Flussmündungen fast immer höher ist als der Oberflächensalzgehalt und gerade für die Bodenbewohner von Bedeutung ist, erfahren wir nichts. Die Angaben über die Variationsbreite des Salzgehaltes an den verschiedenen Stationen erscheinen daher für das Studium der Bodenorganismen ziemlich wertlos. Immerhin ist es von Bedeutung hervorzuheben, dass die Strecke, wo die Salinitätsdifferenzen ihren grössten Wert, etwa 21 $^0/_{00}$ (3.6 $^0/_{00}$ bei Niedrigwasser, 24.3 $^0/_{00}$ gegen Hochwasser) erreichen, auch ungefähr die obere Grenze für die Mehrzahl der marinen Arten bildet. Gerade unterhalb dieser Grenze steigt der Hochwassersalzgehalt seewärts sehr schnell bis auf etwa 33 $^0/_{00}$ und erreicht schliesslich in der Mündung über 35 $^0/_{00}$. Den grösseren, unteren Teil des Untersuchungsgebiets kann man daher als polyhalin resp. marin bezeichnen.

Im kleineren, oberen Abschnitt sind die Verhältnisse komplizierter. Oberhalb und noch ein kleine Strecke unterhalb Weir Head führt der Fluss immer süsses Wasser; eine Kontamination mit Meereswasser findet nicht oder kaum statt. Hier schliesst sich eine brackische Zone, welche bis zum obenerwähnten Grenzgebiet reicht, an. Es schwankt der Salzgehalt bei Niedrigwasser von < 0.1 bis 4.0 $^0/_{00}$, bei Hochwasser von 0.1 bis 20 $^0/_{00}$, sodass der Fluss hier bald vollkommen süsses bald ziemlich salzreiches Wasser führt und eine Trennung in eine oligohaline und mesohaline Zone unmöglich wird; diese beiden Zonen greifen eben vollständig über einander.

Percival teilt nun die von ihm beobachteten Organismen in 4 Gruppen ein und gibt für die wichtigsten Vertreter jeder einzelnen Gruppe auch die obere resp. untere Grenze ihres Vorkommens an.

Die erste Gruppe umfasst die marinen Arten, planktische sowohl wie benthische, welche die sich ändernden Existenzbedingungen schlecht ertragen und unterhalb des schon mehrfach erwähnten Grenzgebiets schnell verschwinden. Diese Gruppe ist die zahlreichste und enthält eine Menge halophiler Arten, welche zur Meeresfauna gehören. Von diesen dringen *Ascidiella aspersa*, *Mytilus edulis* (mit *Alcyonidium mytili*), *Cardium edule*, *Balanus balanoides*, *Leander serratus*, *Sphaeroma serratum* und *Corophium crassicorne* am weitesten vor.

Die zweite Gruppe enthält einige euryhaline Arten, die die Schwankungen im Salzgehalt besser ertragen, wie *Paludestrina stagnalis*, *Scrobicularia*

plana, *Polydora ciliata*, *Nephthys hombergi*, *Obelaria gelatinosa*, *Fucus vesiculosus* u. a., die bis in den oberen Teil des Grenzgebietes vordringen. Noch weiter aufwärts, bis in nahezu süssem Wasser, wurden noch *Carcinus moenas*, *Crangon vulgaris*, *Praunus flexuosus*, *Leander longirostris* und *Nereis diversicolor* gefunden.

Die dritte Gruppe umfasst die genuinen Brackwasserorganismen, die hier teilweise an die Stelle einiger marinen Arten treten. Ihre Zahl ist jedoch gering: *Balanus improvisus*, *Macropsis slabberi*, *Sphaeroma rugicauda* und *Gammarus duebeni* sind die wichtigsten Vertreter des mesohalinen Typs, *Neomysis vulgaris*, *Gammarus locusta* (wohl die var. A?), *Eurytemora affinis* und *Cordylophora lacustris* die des oligohalinen.

Die vierte Gruppe enthält schliesslich nur zwei Arten: *Tubifex tubifex* und *Sphaerium casertanum*, Süsswassertiere, die einen geringen Grad der Versalzung vertragen können.

Während ich für weitere Einzelheiten auf das Original verweise, möchte ich noch eine auffallende Tatsache hervorheben.

Percival gibt an, dass der Salinitätsbereich für *Eurytemora affinis* (Poppe), die den Hauptbestand des Planktons im Flusse bildet und vor einer gewissen Stelle (Calstock) an aufwärts fast als Reinkultur vorhanden ist, zwischen 0.1 und etwa 33 $^0/_{00}$ liegt.

Es erscheint mir jedoch fraglich, ob diese ausgesprochene oligohaline Art wirklich bei so hohem Salzgehalt zu leben vermag. Es liegt hier wahrscheinlich eine Verwechslung mit der ähnlichen *Eur. hirundoides* (Nordq). vor. Es wäre sehr interessant, dies einmal genau zu untersuchen, denn in Holland z. B. gehört letztere zu den typischen Planktern der meso- bis schwach polyhalinen Gewässer und vertritt hier die oligohaline *Eur. affinis*.

Ein ausführliches Verzeichnis sämtlicher beobachteter Arten bildet den Schluss der Arbeit. Der Verfasser unterlässt es, Vergleiche mit anderen Flussuntersuchungen zu machen. Ich halte das für sehr richtig, denn auch die Brackwasserbiologie soll regional betrieben werden. Erst wenn eine grössere Zahl Einzelarbeiten vorliegt, welche unter genauer Berücksichtigung der auch in den Ästuarien von der Bodenbeschaffenheit abhängigen ernährungsphysiologischen und anderen Milieufaktoren das Leben einer, sei es auch kleinen, Zahl von Biocoenosen beschreiben, wird es möglich sein, mit Nutzen Vergleichungen zwischen den verschiedenen Brackwassergebieten anzustellen. H. C. R.

A. C. Stephen. Notes on the Rate of Growth of *Tellina tenuis* da Costa in the Firth of Clyde. Journal of the Marine Biological Association, New Series. Vol. XVI, No. 1. pp. 117—129. Plymouth 1929.

This paper is a direct continuation of the investigations carried out by the author in the Firth of Clyde in 1926 and 1927 (see Review in this Journal Vol. IV, No. 1, p. 123). The size-frequency curves of *Tellina tenuis* are given for March, June and September, 1928, at two stations in the intertidal zone in Kames Bay and at one station on the Hunterston Sands; in addition, some few measurements have been made of *Tellina tenuis* from two stations below L.W.M. in Kames Bay in September, 1928.

As before, the author finds that *Tellina tenuis* shows no growth during the winter months, and that the growth at L.W.M. was less than that near H.W.M. Taken as a whole, the rate of growth during 1928 was of the same order as that of 1927; yet one of the stations above L.W.M. showed less growth in 1928 than in 1927; in 1927 also the rate of growth from March to June was greater than that from June to the beginning of October, but in 1928 the position was reversed.

From a study of the size-frequency curves for 1928 the author finds his view of a missing year-group (1925) on the curve for 1926 to be confirmed.

It is a curious fact that there were no signs of any growth or of year-groups at the stations below L.W.M. There had, however, been a very heavy mortality from September, 1926, to September, 1928. This is explained by the author in the following way. Huge numbers of the spat of the rich year-group 1926 settled on this ground during the summer and autumn of 1926, causing overcrowding to such an extent that the food supply proved insufficient. Therefore the growth became slight, the mortality high, and the year-group 1926 is now dying off.

On Hunterston Sands at Perch the 1926 spat still dominated in the samples of April and June, 1928, but in the samples of September, 1928, this year-group had gone; only the empty valves were found in large numbers; they were whole and therefore not taken by fish, but what was the cause of the mortality here, was not apparent.

By an examination of the modes of the 1926 spat on the different size-frequency curves the author found the yearly increment for this year-group at two stations to be 4 and 6 mm., respectively, in 1927 (the I-group), but only the half (2 and 3 mm., respectively) in 1928 (the II-group). This result is in accord with that which Orton has found for *Cardium edule*; the author points out that if it holds good for all Lamellibranchs that each annual increment is approximately half of the preceding year, we have a means of estimating the age of the numerous small, but from the economic point of view important, species, when only the first full year's increment is known. In the opinion of the present reviewer the matter is, unfortunately, not so simple; the growth rate of several of the Danish Lamellibranchs seems, at all events, not to follow this rule.

H. Blegvad.

K. Altnöder. Untersuchungen an den Heringen der westlichen Ostsee und Bericht über die Untersuchungsfahrt zur Feststellung des Vorkommens von Herbstheringslarven in der Laichperiode 1927. Berichte d. deutschen Wiss. Komm. f. Meeresforschung, Neue Folge, Bd. IV, H. 3. Berlin 1928.

The author deals with a large number of herring samples from the German coast of the western Baltic from Rügen Island to the Danish frontier. He studies especially the spring spawners in regard to their racial characteristics, state of gonads, size and spawning places, and he has obtained a number of valuable results.

He gives the characteristics of the spring spawning herring which are taken with the purse seine in Lübeck Bay. The main characteristics are:

Vert. S.	Vert. praeh.	K_2
55.42	23.38	13.87.

In the spring this herring migrates to the Dassow Sea (an enlargement of the lower part of the river Trave) to spawn in shallow water of salinity 9 to 10 ‰ and at a temperature of 11° C. The first larvae were caught on the 30th April. By the 14th June most of the larvae had reached a length of 3 cm., by the 29th July 4 cm., and by the 30th August 4.5 cm. During September these young herrings disappear into the Baltic. In June the following year the average length is 10—11 cm. The majority of these herrings at a length of 21 and 22 cm. were three years old.

A sample of the spring spawning herring from Schley, a brackish-water bay North of Kiel, shows differences from the Dassow Sea herring.

The author is further of the opinion that the spring spawning herring from Fehmarn Island is different from the brackish-water herring referred to, but identical with the spring spawning race from the Great Belt. This race also is perhaps distributed as far to the East as Rügen.

The author gives an interesting report on the purse seine herring fishery in Lübeck Bay, which started in 1918. He points out that the decrease in the total catch during recent years is not caused by any sort of overfishing, but by the fact that the fishing is not being carried on so intensively as during previous years.

These herrings taken with the purse seine consist of spring and autumn spawners, and the author has studied many samples from the catches, but has not quite succeeded in defining all the races. He says himself that many questions concerning the purse seine herring are still to be solved.

Furthermore, the author gives a report on the catches of herring larvae during the cruise in October 1927 from Travemünde northwards to Flensburg, thence eastwards to Stralsund and round Rügen, and he discusses the possibility of locating the spawning places from a consideration of the catches of young larvae. In conclusion, from the occurrence of larvae with yolk-sacs he supposes that the autumn spawning herring have their spawning places in the regions West of Fehmarn, and from Travemünde to Rügen and round this island.

The author also deals with certain other larvae, which were collected during the cruise.

K. A. Andersson.

A. Bückmann. Die Methodik fischereibiologischer Untersuchungen an Meeresfischen. Aus: Handbuch der biologischen Arbeitsmethoden, her. von Prof. E. Abderhalden, Abt. IX, Teil 6. Berlin 1929.

The daily work of the fishery biologist consists in the treatment of data which are of a statistical nature. An isolated observation scarcely matters; it is the mass of observations collected at the same time and the same locality, and repeated observations at that, which we have to deal with. How this extensive material, constantly accumulated, might be treated was first indicated by Heincke who introduced the methods of mathematicians such as Quetelet, Fechner, Pearson and others into biology. It is by no means easy to explain the different formulae used (and the

present reviewer confesses to a particular aversion from all formulae), but Dr. BÜCKMANN handles them with the ease and grace of the perfect master who knows how to deal with this formidable matter.

The paper is made up of four chapters, each with subdivisions. The last two chapters are by far the most voluminous and of the utmost importance.

In the first chapter it is stated, right from the beginning, that, after a period of general investigation into the life history of any fish species, the problem of the mode of life of the "stock", i.e., the totality of individuals of a given species in a sea territory which is more or less to be regarded as an ecological unit, should be considered. This problem is essential from the point of view of practical fishery and that of overfishing. The author rightly points out the importance of fish marking experiments, which furnish data not only on the migration of the species but also on the mortality caused by the fisheries among the species concerned (of course, taking into account a certain percentage that, being unmarketable, is immediately discarded). Between "mortality" and "productivity" a certain balance must of necessity exist, and the cause of every disturbance is to be sought for. Practically we can in most cases deal only with "mortality" caused by the agency of man, other causes being of a much more obscure nature.

How the abundance of a certain "stock" of fish may be judged has been treated in the second chapter. Our methods are the analyses of catches, either on board ship, using scientific methods (in which connection various nets used in capturing plankton or bottom animals are discussed) or at the market. The obvious disadvantages of the latter method, when one is restricted to the material present, are to some extent overcome by using sea-going measurers, but on the other hand the working of these measurers is, through press of time, limited in practice to measuring only.

The scope of the third chapter (statistical method in fishery biology) is devoted to the mathematical treatment of frequency tables. This chapter, together with the next, is of the utmost importance to the fishery expert, who in his daily routine is constantly using and applying complex formulae without bothering much about their deeper significance, but it goes without saying that this subject does not lend itself to a limited and superficial review. We have discussions of "smoothing" of curves; calculation of values (deciles, quartiles, mean average) and of standard-deviation and mean error; positive and negative correlation between characters in statistical treatment; calculation of coefficient of correlation and its standard-deviation — the whole fully illustrated by examples; regression is also discussed at the end. It is the provision of examples which, calculated according to the formulae commonly used, is really indispensable in a paper like this.

The fourth (and last) chapter deals with special applications to fishery statistics of the methods discussed. First, however, we get a discussion of statistics and the use of certain units which might serve as reliable guides in estimating the productivity of any sea-territory. The German method of subdividing the North Sea into depth areas is mentioned as well as the English use of the well-known "squares" which have

become in the last few years a characteristic basis for the English statistics. With regard to the German statistics of the herring drift-net fishery still smaller squares might be made use of (LISSNER). In statistical treatment time is also to be taken into account (for many species the quantity is given for the whole year, for the seven principal kinds of fishes for each month separately, with the trawled herring fishery of Altona even per 10-day period). This is followed by a discussion of the intensity of fishing (days absence from port or 100-hours fishing) which is of course a most important feature of these statistics; disturbing factors (in using days at sea as a unit) are the unproductive periods (gales and other impeding influences, shifting of position, etc.). Also we have to keep in mind the catching capacity of various types of craft and nets. In short, we are confronted with a number of difficulties, but, for any branch of the fishery, the safest argument is the number of actual fishing hours, as is employed in the English statistics. Other countries, e.g. Holland, which content themselves with days of absence from port and, moreover, treat the North Sea as a unit, have not yet reached such a high stage of precision, but it should be borne in mind that the most exact scheme reveals its weakness, in so far as it depends upon information which can be controlled only in an unsatisfactory way.

Analyses of market samples, though indispensable as a basis of our judgments on the fishery, present their difficulties. The various "sorts" distinguished for any given species not only fluctuate in different ports, but may do so even in the same port in the course of time. Yet it is market statistics and analyses of market samples which are to help us in tackling important problems relating to the yearly quantity of any given species in a more or less limited area, the fluctuation of these yearly quantities, the intensity of fishing etc. What is to be borne in mind and how material at the market may be treated is explained in the course of several pages.

The second part of this fourth chapter deals pre-eminently with the marking of fish; how material suitable for this purpose may be obtained and treated; which marks are used in different countries and how these are to be attached. These methods have been criticised a great deal, but we may nevertheless gain from them some insight into migration and growth, to say nothing of the criterion of fishing intensity on a certain "stock" which may be obtained by such experiments.

The author then passes on to scientific methods of frequency determination of a "stock" by means of repeated catches with the same net at the same locality in a unit of time, which, if effected in different seasons, may furnish some idea of seasonal distribution on the particular spot. Many disturbing factors are of course likely to present themselves and sampling must be repeated often. We then proceed to measuring, in which also many errors, mostly due to insufficient material, are likely to occur. The same holds true for weighing. After the mathematical discussions it is refreshing to reach at last a biological discussion of determination of sex and maturity, in which clear and simple illustrations afford great help. Age determinations, especially by means of otoliths and scales, and the obstacles encountered in their interpretation induce the author to mention the fluctuations in fisheries, which are nowadays

much to the fore. LEA's method of calculating the length of the individual herring is of course discussed, together with the criticisms of ROSÁ LEE and MOLANDER.

After discussing investigations of the food of fish the author proceeds to the vexed race problem. The points to be kept in mind, after discarding such characters as are dependent on age and sex, and the choosing of right characters, either morphological or physiological, are amply treated. Preferable characters are those which can be counted, and several illustrations are given to avoid misunderstanding. How to recognise mixture of races, which is of frequent occurrence, not only by mathematical treatment, but also by the maturity of individuals, is clearly treated. At the end we get a discussion of methods used in investigating pelagic fish eggs: how the eggs, apart from morphological characters, are to be distinguished by measuring them under the microscope; how mixture of two kinds of eggs is to be detected and how the quantities of each can be found by extrapolation, and how the stages of development of the egg may be ascertained. Finally the explanation of BUCHANAN-WOLLASTON's method of interpolation is given, which is used to ascertain the locality of maximum egg density; in other words, the spawning locality.

A work like this, with its mass of mathematics and discussions of algebraic formulae demands for its perusal a firm grip of the intellect, and an unflinching will.

Hearty congratulations on fulfilling the laborious task of composing a useful and indeed badly wanted handbook are due to Dr. BÜCKMANN.

J. J. T.

K. DEMEL. Sur la distinction des races des harengs pêchés près de la côte polonaise. Archives d'Hydrobiol. et d'Ichtyol. T. III, No. 3—4. Warszawa, 1929. pp. 15, figs. 2. (En polonais avec un résumé en français.)

L'auteur constate l'existence de deux races des harengs pêchés sur la côte polonaise: une automnale, frayant au mois de Septembre et d'Octobre et une printanière, frayant au mois de Juin. La race printanière est bien rare, l'automnale au contraire est prédominante dans les pêches de toutes les saisons. Les poissons de la dernière race, pêchés pendant toute l'année diffèrent bien en leurs dimensions. Il est possible que les bancs constitués des individus les plus grands proviennent d'autres parties de la Baltique que les poissons de petites dimensions.

M. S.

P. JESPERSEN. Investigations on the Food of the Herring in Danish Waters. Meddel. Komm. f. Havundersøg. Serie Plankton. Bd. II. No. 2. København 1928.

This report is the first comprehensive work on the food and feeding habits of the herring in Danish waters, and is a welcome addition to our knowledge on this subject. The material is extensive, including the examination of the contents of the stomachs of 7316 herring collected during the period November 1922 to April 1926. Of these 2827 were larval, post-

larval and metamorphosing stages with a range of length of 4—50 mms., and 4489 were young herring (6—17 cm.) and adults (17 cm. and over). In addition 250 plankton samples were collected at the same time as the herring samples, and their analyses are compared with those of the stomach contents.

Most of the adult herring came from four regions: Rudkøbing; The Sound and Køge Bugt; Samsø; and Frederikshavn and Læsø Rende. The young herring (6—17 cm.) were, on the other hand, principally taken from stations off the North Sea coast of Jutland. The youngest stages were from a much wider area.

Hardy (1924) in tabulating his herring stomach data, endeavoured to give each species of animal its approximate value in relation to the others, and took copepods, *Oikopleura* etc. as units, while *Ammodytes* (sand eels) of 52 mm. length were assessed as 1000 units, schizopods as 20, and so on. In this paper this method is rejected as unsatisfactory, and the data are shown as 1) Frequency of occurrence (the relative number of feeding herring in which the various organisms were present as part of the food) and 2) Quantity (the average number per herring of the different organisms found, where the respective organisms formed part of the stomach contents).

The food of the larval herring consisted of a small quantity of greenish-coloured food which was unidentifiable. Only a few larvae had any food at all. When the yolk sac had been absorbed, however, the larvae began to feed quite definitely upon phytoplankton, and as the length increased they changed over gradually to animal food, beginning with copepod nauplii, copepod ova and young copepods, while later adult copepods and cladocerans formed part of the diet. Up to a length of 19 mm. 22—40 % contained food whilst above this length (up to 36 mm.) the percentage feeding had increased to between 50 and 100. Practically all the metamorphosis stages (38—50 mm.) contained food. There was a greater variety of forms, but copepods constituted the principal diet. It will be seen therefore that in the youngest stages of the herring there was a progressive increase in the percentage feeding as growth proceeded. Dr. Jespersen's results are closely similar to those obtained by Hardy in 1922—23.

Young herring (6—17 cm.) fed briskly at all seasons and no fewer than 95.5 % contained food. Copepods continued to be the staple diet, but in summer and autumn, cladocerans also were consumed in appreciable numbers. Gastropod larvae and decapod larvae also occurred in autumn in some localities, while in others, polychaetes, chaetognaths and appendicularians were of importance. In the North Sea (Graadyb), while copepods were predominant in winter, mysids, amphipods and cumacea were important additions to the diet.

Adult Herring (ca. 17—30 cm.). The most interesting result of the investigations is that the feeding of adult herring in Danish waters is continuous throughout the year. Taking an average of all the samples it is found that there is a rise in the summer months and a slight fall in autumn, but there is no period when food was quite absent as is the case for English herring during the autumn and winter months, as shown in Hardy's report. The average percentage of adult feeding herring for the

whole period covered by the investigations was 57.2, compared with HARDY's figure of 24.1 %.

The principal food was undoubtedly the crustacea, of which the copepoda were of predominant importance. 93 % of the feeding herring contained crustacea, whilst non-crustacea were taken by 32 %. The order of importance for the different food elements is shown by the following percentages of occurrences in all adult herring examined: Copepoda 74.4, Cladocera 17.8, Fish ova 13.0, Amphipoda 11.5, Decapod larvae 11.2, Mysidacea 8.8, Isopoda 6.5, Gastropoda larvae 6.5, Fishes 4.5, and Polychaetes 4.2. All other organisms had less than 4 % of occurrences. Some marked differences in the composition of the food were found in herring from the four principal localities: certain genera of copepoda (*e.g. Acartia*) and cladocera were found mainly or only in herring from the Sound; mysids, isopods, and cumacea were characteristic of herring food at Rudkøbing; larval gastropods at Samsø and Frederikshavn; whilst polychaetes were absent in the herring stomachs from the Sound, but fairly common elsewhere. The principal copepods present were *Paracalanus parvus*, *Pseudocalanus elongatus* and *Temora longicornis*. *Calanus finmarchicus*, so characteristic of the food of North Sea herring, was very scantily present, and the same remark applies to *Oikopleura* spp. and Hyperiid amphipods. Generally speaking, there is agreement between the stomach contents and the plankton catches, but Dr. JESPERSEN concludes that the herring do not feed indiscriminately on the plankton, but by selecting certain organisms in preference to others.

Seasonal changes in food. Copepods were predominant in winter and spring but decreased in numbers during the summer and were comparatively few in autumn. In summer and autumn there were maximal occurrences of cladocerans and polychaetes (May—August); decapod larvae (July—September); mysids, amphipods, isopods and fishes had their maximum occurrences between July and December. Fish eggs were present generally throughout the year, but had their maximum during the herring spawnings in spring and autumn, when they consisted of herring eggs.

Feeding in relation to Maturity. Measurements of the size of the gonads were made on preserved material and the stomach contents noted. The general conclusion arrived at was that immediately before and during spawning less food was taken, this being most obvious in the autumn spawners. Spring spawners from Rudkøbing and Samsø, however, often had considerable quantities of food in their stomachs.

Young herring were much keener in their search for food than the adults and the relative number containing food was always greater than that for adults, while the average number of organisms per fish was also greater. Some experiments on the times of feeding were carried out on young herring from Graadyb during the winter months. Hauls were made at different times of day and night and the results show that they fed mainly by day, little or no feeding taking place during the night.

Tank experiments on the time taken in the digestion of food were also made. Freshly-caught young herring were placed in tubs which had been filled with filtered sea-water, so that no further food could be taken. Some

of the herring were killed at intervals of 3 hours. The results showed that food remained in the stomach for considerable periods; the quantity was only slightly reduced during the first 12—15 hours, and after a lapse of 21—24 hours several of the fish still had food in their stomachs, and some even up to 29 and 39 hours. Considerable variation was shown, however, and the results are not claimed to be conclusive. R. E. S.

GUNNAR ROLLEFSEN. Torske-egg med deformerte fostre. Norges Fiskerier 1929. No. 2.

The occurrence of dead and deformed eggs in the plankton hauls is well known to all scientists dealing with fish eggs.

As to the cause of mortality, however, we do not know very much. This problem has caught the interest of a young Norwegian scientist, cand. mag. GUNNAR ROLLEFSEN, and in the paper mentioned we get a report of the results obtained by him during the last season at Lofoten.

On examining the dead eggs it was found that the majority were in the very early stages. During some hatching experiments the same types of eggs occurred, and as Mr. ROLLEFSEN thought that death in this case was caused by rough handling, he constructed a "shaking mechanism" in order to try the hardiness of the eggs. A glass cylinder was fastened to a vertical, rotating board. The cod eggs were put into the cylinder together with sea-water, but the cylinder was not quite filled. On moving the board quite slowly, the eggs and water would stream from one end of the cylinder to the other. A few slow rotations were sufficient to bring about the characteristic features, which appeared in a minute or so after the shaking. The yolk membrane burst and the germinal disc became contracted and deformed.

As the violence used was quite moderate, Mr. ROLLEFSEN put forward the working hypothesis that in Nature the cod eggs must surely be damaged by the breaking waves. As the dead egg normally sinks, he tried to find the dead eggs on the bottom of the sea, and was successful. They had the characteristic appearance, but whether they had been destroyed by the waves or in any other way could of course not be settled.

After looking through the meteorological observations for some years the author stated that the best brood years are those with off-shore winds predominating, i.e. small waves. This phenomenon strengthens his theory — but, as the author says, off-shore winds will also act upon the currents etc. and the correlation may be quite a different one from that mentioned.

The reviewer is of the opinion that the wastage of the fish eggs and larvae in Nature is a most important one. Some years ago I had the opportunity to examine the eggs and larvae caught in the Lofoten waters by Dr. JOHAN HJORT in 1913[1]). I found the following number of cod eggs in the different stages of development:—

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[1]) Fiskeegg og yngel i Lofoten. Report on Norwegian Fishery and Marine-Investigations. Vol. III. No. 3.

	Stage I		Stage II		Stage III	
	Number	%	Number	%	Number	%
Inner part	73656	58	48563	39	4164	3
Outer part	139599	91	13059	9	149	0
The whole Vestfjord	213255	76,5	61622	22	4313	1.5

156 cod larvae were also found. As will be seen from the table, the occurrence of eggs in late stages is very poor especially in the outer part of the fjord, where the waves must be expected to be more violent. This is in favour of the views put forward by Mr. ROLLEFSEN.

But the breaking waves are surely not alone responsible for the great wastage. If the waves were the one and only factor, the degree of survival of the eggs in smooth waters and in waters with a brackish top layer, where the eggs cannot float, ought to be quite extraordinary. But this is apparently not the case. ALF DANNEVIG.

W. SCHNAKENBECK. Beitrag zur Kenntnis der Entwicklung einiger Meeresfische I. Bericht. der Deutschen Wissenschaft. Komm. für Meeresforschung. N. F., Bd. IV. Heft 4, Berlin 1928.

The German Fishery Research Steamer "Poseidon" has in recent years surveyed the spawning places of the autumn herring in the northern North Sea and investigated the dispersal of the larvae. The results of the earlier cruises have already been published in whole or in part while a preliminary notice of another has appeared in the Fischerbote (November 1928). During a cruise in October 1922, from the Dogger Bank through the Gut to the Fladen Ground, no spawning places were found in the deeper water offshore. MIELCK[1]), however, recorded considerable numbers of larvae, from 10 to 30 mm. in length, in the region of the Gut and the interpretation — probably the correct one — put on their occurrence was that the smallest larvae, at least, were derived from the great spawning centre E. to N.E. of Rattray Head. The cruise, with which the paper now under review deals, was carried out at the end of August and first half of September 1925 and was mainly coastal from Newcastle to Peterhead, stormy weather having limited the observations in an easterly direction. Herring larvae were taken in abundance with the Young Fish Trawl during the first week of September at the northern stations from Peterhead to the mouth of the Ythan (North of Aberdeen) as shown in Table III. Eighty per cent. of the total larvae in the catches were 10 mm. or less in length, while the few remaining larvae ranged from 11 to 18 mm. A percentage of the smallest larvae was still in the yolk-sac stage, indicating proximity of the northern stations to a hatching incidence.

The regular and rapid decrease in the numbers of herring larvae from the smallest to the largest size in the capture by plankton nets is here in

[1]) Bericht. Deutschen Wissenschaft. Komm. Meeresforschung Neue Folge Bd. I (1919—1923), 1925.

evidence and may be explained, apart from the selective action and possible inefficiency of the nets in use, by mortality and dispersal over a wider area. The observations were made at the time when hatching was most intensive so that the abundance of small larvae in the catches off Peterhead was probably largely due to chance sampling before the waves of larvae had become scattered and thinned out. The few larger larvae in the catches at the northern stations had probably been carried into the area from incidences farther North. Table III also indicates a southern incidence, as larvae less than 10 mm. in length (though few in number) were taken at stations 17 to 19 — South of the Forth, thus showing that hatching had begun very early in this region. The presence of slightly larger larvae at the same stations is probably evidence of an influx from earlier hatching to the North. The relation of the occurrence of larvae to the currents prevailing here, however, requires more detailed observation and can only be elucidated by a sequence of similar cruises during and after the hatching periods. The outline of the general planktonic conditions in Scottish waters, given in the 44th Report of the Fishery Board for Scotland, shows that conditions in 1925 were similar to those in the autumn of 1920 when abnormal numbers of Salps were found within the North Sea. These conditions rather tended to upset the normal course of events, some hatching having occurred even as late as December. The Scottish records also demonstrate the occurrence of successive waves of newly hatched larvae off the Aberdeenshire coast and in the Moray Firth during September and October of the same year (1925), which in all probability was the result of an influx of successive spawning shoals to these grounds. The German records, therefore, provide extremely useful additions to the data obtained from the more continuous Scottish observations in the same area.

During the cruise of the "Poseidon" in August 1928, according to Ehrenbaum, (Fischerbote, Nov. 1928) the whole extent of the East Scottish coast from Berwick to the Shetlands was sampled, while easterly extensions were made across the Fladen Grounds, the Gut and southwards over the Dogger Bank. Hatching had begun to a small extent at Fair Isle and to a much greater extent close to Rattray Head. Larger larvae extended coastwise as far as the Tay, but were absent elsewhere, being replaced in the catches on the more southern grounds by Sprat larvae.

The papers by Mielck and Schnakenbeck are enriched by short studies of the larvae of other fishes taken simultaneously with the herring. Schnakenbeck identifies 27 species and mentions unidentified forms of other two genera. Detailed descriptions and figures are given of 13 of these species, all already wellknown. One is tempted to criticise some of the illustrations, particularly the figures of the Witch (*Pl. cynoglossus*). Compared with the richer material of the Lemon Sole they are weak and give a poor representation of the much larger size and more elongated form of the larval Witch. It is questionable whether the method of drawing the illustrations has any advantages over diagrammatic reproductions, which, after all, are usually taken from perfectly preserved specimens or a combination of specimens. In the text figures there are minor innovations in figuring the arrangement of the larval teeth, opercular spines and caudal rays for specific diagnoses, and

the block figures of the caudal plates confirm the work of PETERSEN[1]) (C. G. J.) who has already made clear the specific value of the number of caudal rays in the genus *Pleuronectes*.

The captures of Hake larvae are interesting and their distribution along the Aberdeenshire coast agrees with the more extensive information from the Scottish plankton researches, but their occurrence in the North Sea is sporadic and they cannot be said to occur every year to the same extent. The captures of larvae — other than herring — were not sufficient to give a representative picture of each species but gaps were filled by material from the Fishery Institute at Hamburg. This procedure is questionable in some cases when the complete metamorphosis may not be attained in the area under investigation. The preponderance of herring larvae over other species is very pronounced, the lateness of the period of observation being largely responsible for this. The measurement of every individual in very large catches may sound tedious and unnecessary but some process such as the arrangement in size categories of 5 mm. increment might overcome this difficulty, and appears to be more desirable than calculating the frequencies from the measurements of part of the sample. The recording of species other than herring, however, is praiseworthy. There are always some related biological factors which may shed some new light on the biology of the herring. R. S. C.

B. STORROW and D. COWAN. (a) Herring Investigations. 1. Herring Shoals, by B. STORROW. 2. Size, by DOROTHY COWAN. Dove Marine Laboratory. Report for year ending June 30th, 1928, N. S. XVII. Newcastle-on-Tyne, 1929.

(b) Herring Investigations. 1. Herring Shoals, by B. STORROW. 2. Size, by DOROTHY COWAN. Dove Marine Laboratory. Report for year ending June 30th, 1929, N. S. XVIII. Newcastle-on-Tyne, 1929.

In these two papers Mr. STORROW gives a review of the results of his examination of samples of herrings during 1927—28 and 1928—29. The samples covered a very wide field, comprising such widely separated localities as Yarmouth, Shetland and Donegal, and numbered fortynine with a total of 8,868 fish.

As each area has its own peculiarities any attempt to summarise the results would be of inordinate length and it must suffice to note the prevailing year-classes in each locality and to call attention to some of the theories of distribution which are suggested, rather than expressly formulated, in the paper.

Mr. STORROW adopts the convention of assuming that the winter ring is formed between 31st December of one year and 1st January of the next and refers each year-class to the year preceding the formation of the winter ring. This is a reasonable course as it gives the observed facts without involving any estimate of the probable date of hatching.

The most abundant year-classes were:—

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[1]) Meddel. Komm. Havunder. Serie. Fiskeri Bind II, No. 1, 1906.

In 1927 — Killybegs (W. Donegal) 1924, 1921; Buncrana (N. Donegal) 1924, 1921; Lerwick 1923; Firth of Forth 1926, 1925; Yarmouth 1925, 1922.

In 1928 — Killybegs 1925, 1924; Buncrana 1925, 1924; Girvan 1925, 1924; Wick 1923; Lerwick 1924, 1923; Eymouth (Firth of Forth) 1925, 1923; Yarmouth 1925, 1922.

In 1929 — Buncrana, 1925, 1924; Girvan 1925, 1924; Wick 1925, 1924, 1923; Lerwick 1924, 1923; Firth of Forth 1927, 1925.

The noticeable feature in these three years is the scarcity of the Y.C. (year class) 1926, which only appeared once in any considerable numbers, as a local shoal of one winter ringed fish in the Firth of Forth, taken in December 1927. On the North Coast of Ireland and on the West and North Coasts of Scotland 1925 and 1924 were the outstanding year-classes, swamping the survivors of 1921 which lingered off the Donegal coast. Off Yarmouth Y.C. 1922 survived in force till 1928.

To explain most of these occurrences Mr. Storrow brings forward a theory of extensive migrations, the older fish being regarded as having a tendency to move northwards and away from shore. He suggests, e.g., that the N. of Scotland herrings after five or six years move to the Shetland area and thence later to an unknown destination. In support of this view he points out that the Y.C. 1918, which had disappeared from the Wick catches after 1923, persisted off the Shetlands till 1926, and the Y.C. 1923, which was prominent off Wick in 1926 did not take a leading place in the Shetlands till 1927.

In the case of the banks off Girvan, in his first paper he regards the migration as being determined by the frequentation of the spawning grounds by fish of a definite uniform size, 26—27 cm., the larger fish moving off to other grounds. Subsequent sampling in 1929 has apparently raised the upper limit to 29 cm.

Several instances are quoted of the occurrence of samples showing both high and low growth rates in adjacent localities. Of two samples taken in 1928 in the neighbourhood of Wick, that taken more to the eastward had the higher growth rate and it is suggested that this was due to a period of feeding in the rich area between the Norwegian and the North Sea, the more westerly sample being regarded as typical of the Atlantic. Other Wick samples, taken in 1929, showed such a low growth rate that their origin is referred to the southward, possibly to the Firth of Forth.

Great stress is laid on the occurrence of "marked scales", i.e. scales with wide growth zones outside narrow ones, as evidence of a change of habitat from one year to another.

The occurrence of selective shoaling, i.e. the more rapidly growing young fish consorting with older fish of a similar size, and the chances of a year's spawning being exceptionally productive are both alluded to, but not much weight is attached to either of these possibilities as explanations of observed distribution of year-classes.

Taking the papers as a whole, a rather complicated picture is presented of areas populated at the same time or successively by shoals of very

varied origin, but a key to all these movements is indicated in the varying force of the Atlantic current. No actual hydrographic data are quoted but faunistic indications are given of an abnormal influx into the North Sea in 1926 and 1927, diminishing in 1928 and by its reflux, relatively speaking, producing in 1929 a general transfer to the west and south of migrations which previously had a more north easterly range.

Whether these migration theories are ultimately verified or disproved, there can be no question about the value of the data which Mr. Storrow has been bringing together yearly since 1919. In many cases they are the only records available of the size, age and maturity of the dominant groups in several important fisheries, and we must be duly grateful to him for them, and also to his colleague, Mrs. Cowan, who has tabulated and summarised the sizes of the various age groups in the samples which were examined. G. P. F.

L. Joubin (edited by). Faune Ichthyologique de L'Atlantique Nord. Nos. 2 & 3. Cons. Perm. Int. pour l'Exploration de la Mer. A. Höst et Fils. Copenhague.

The second and third parts of this interesting and valuable work have now appeared, and, under the able editorship of Professor Joubin, fully maintain the high standard set by the first part issued in 1929. Descriptions and figures of a further series of fishes of the coasts of Western Europe are issued as separate sheets, each of which is devoted to a single species. In certain cases two sheets are given to one species, the second being devoted to the larval and post-larval stages. The arrangement of the subject matter has been outlined in my review of the first part (Journ. Cons. Int. Explor. Mer., V (1), 1930, p. 122), and need not be repeated here. In the parts now issued the text is either in English, French or German, and is the work of such well known authorities as d'Ancona, Bertin, Chevey, Clark, Ehrenbaum, Fage, Le Gall, Ramalho and Schnakenbeck, among others. Twenty-four species are dealt with in Part 2, and twenty-two in Part 3, but considerations of space make it impossible to give a list of the names here.

In a collective work of this nature the different sheets are inevitably unequal, not only in their scientific value, but in their appeal to the individual. In the writer's opinion those which describe and distinguish the closely related species of *Beryx* and *Arnoglossus*, and those which deal with the Grey Mullets (*Mugil*), an extremely difficult genus from the taxonomic point of view, are particularly good, whilst those which describe and figure the larval and post-larval stages of the better known Heterosomata should prove of special interest. Many of the figures, notably those of *Arnoglossus* and *Beryx*, leave little to be desired, and provide valuable aid in distinguishing closely allied species which even the specialist finds some difficulty in identifying. These beautifully executed line drawings are to be preferred to the photographs which have been used to illustrate some of the species, the latter often failing to reveal the characteristic features of the fish in question. It is to be regretted that in the case of *Hippoglossus vulgaris*, *Selache maxima*, *Mugil auratus* and *M. cephalus*,

use has been made of the old figures of DAY and of CUVIER and VALENCIENNES, figures which are often far from accurate.

Most of the points of criticism concerning the taxonomic and nomenclatorial details given in my previous review apply equally to Parts 2 and 3. In several cases the name given is that which conforms to the international rules of nomenclature, but in others these rules appear to have been ignored and the name which heads the sheet is not that which has priority, but that which has been in general use for some time. The following example will suffice to illustrate this point. The Spiny Dogfish or Spur Dog was first described by LINNAEUS in 1758 as *Squalus acanthias*, and there can, therefore, be no justification for the use of the name *Acanthias vulgaris*, first given to the species by RISSO in 1826. J.R.N.

C. McC. MOTTLEY. Pacific Salmon Migration. Report on the Study of the Scales of the Spring Salmon *Oncorhynchus tschawytscha*, tagged in 1926 and 1927 off the West Coast of Vancouver Island. Contrib. Canad. Biol. and Fish. N.S., Vol. IV, No. 30. Toronto, 1929.

The ocean fishery for salmon off the coast of Washington and of British Columbia provides an opportunity for studying the sea phase of the life history of the Pacific forms such as is not available to investigators dealing with the Atlantic species. The fish are taken by trolling on and around the banks situated on the continental shelf which is about thirty five miles wide and several hundred miles long.

In the paper under review Mr. CHARLES McC. MOTTLEY deals with the spring (or King) salmon, *Oncorhynchus tschawytscha*, and obtained his material from marking (tagging) operations conducted off the west coast of Vancouver Island in 1926 and 1927.

Altogether a little over 1600 fish were marked of which a return, only in the year of marking, of approximately 11 per cent. was obtained in recaptures. Upwards of half of the recaptures were in, or at the mouth of, the Columbia river, the remainder being distributed between the Sacremento, Skagit, Fraser and many smaller streams along the coast. It would appear therefore that the majority of the spring salmon found off the west coast of Vancouver Island originate in the Columbia river.

In view of the fact that some at least of the fish belonged to groups not maturing in the year of marking, and of the intensity of fishing, the proportion of recaptures and the lack, so far as reported, of any in subsequent seasons, is perhaps disappointing and might possibly suggest that some of the marks were lost from the fish after a comparatively short time.

The young spring salmon have two distinct habits of migration. The majority (80 per cent.) leave during the fry stage and the minority (20 per cent.), believed to be those from the upper spawning tributaries, do not do so until a year later. The transition of both types from fresh to salt water is spread over the greater part of the year and the recapture records would seem to show that when they reach the sea all turn northwestwards in the direction of the prevailing coastal current. In feeding vigourously they take advantage of the local concentrations of suitable

food supply (herring, pilchard, sand launce) and the men who fish for the market by trolling spoons astern of their boats are at pains to discover the shoals of larger and older fish. They may even ignore the younger shoals of smaller sized specimens and stay ashore until the more valuable are located.

Among the immature fish the "dispersal" is a continuous process with possible fluctuations during the winter. Up to the fourth and fifth years a higher proportion of the older age groups are found towards the north-west end of Vancouver Island than in the neighbourhood of the Columbia river. The majority of the stock mature in their fifth and sixth years and only cease feeding on approaching the coast. In the great majority the slow growth period ends in March or April but in some of the older fish the recommencement of rapid growth is retarded as is the case in older *Salmo salar*; among the older spring salmon specimens were found at the beginning of May with the winter band still at the margin of the scale.

Mr. MOTTLEY has given us a very complete analysis of the life history of the fish under his review but we feel the lack of any indication of the sizes, length or weight, of the age groups to illustrate the reaction of the early manner of life on the subsequent growth. His explanation of the checks on the scales as indicative of a period of injury, e.g. owing to the bite of a shark, is ingenious but would not explain the similar occurrence observed on the scales of European Atlantic salmon since the latter has been shown to be formed in a large proportion of the stock at the same period (end June—early July) every year. Mr. MOTTLEY also adopts an unusual process for examination of the scales viz. mounted in glycerine jelly or placed in water. Both of these methods have been found to be unsatisfactory for the scales of all other salmonidae, the areas and markings on which are much more clearly differentiated and observed if they be examined dry when held between two glass slips. The scale illustrations which accompany the paper are so indifferent as to be almost useless for purposes of comparison. W. J. M. M.

LUIS LOZANO REY. Fauna Ibérica—Peces. — Tomo primero, Madrid, 1928, pp. XII—692, figs. 197, pls. 20.

La faune ichthyologique, tant maritime que des eaux intérieures, de la Péninsule Ibérique offre un intérêt indubitable. De par sa situation géographique, pour ainsi dire dans la jonction de trois aires bio-géographiques assez différentes (Atlantique Septentrional, Atlantique Tropical et Méditerranée), aussi bien que par la variété de conditions mésologiques, soit de l'eau soit des fonds, le fait est qu'on trouve une grande richesse d'espèces dont l'étude plus détaillée a reçu dernièrement un développement assez marqué.

Après les travaux déjà anciens des ichthyologistes espagnols, portugais et étrangers à la Péninsule, tels que le renommé STEINDACHNER, de Vienne, qui ont exploré la région et laissé des catalogues ou des listes plus ou moins complètes et embrassant une aire plus ou moins vaste, le besoin se faisait sentir de plus en plus pressant d'avoir un ouvrage d'ensemble où on puisse trouver réunis non seulement la liste de toutes les espèces

fréquentant les eaux ibériques mais aussi leur description, leur représentation et tous les faits qui aident à bien les connaître et reconnaître. Tel est l'entreprise dont ce premier volume de l'ouvrage de M. le Prof. Lozano nous annonce si brillament la pleine réalisation.

Il ne faudrait point limiter au Prof. Lozano seulement, les louanges que cette publication mérite; il est de toute justice de les adresser aussi à la "Junta para Ampliación de Estudios e Investigaciones Cientificas", de Madrid, institution dont les considérables bienfaits scientifiques se sont toujours manifestés depuis sa fondation par l'Etat Espagnol, il y a déjà plus d'une vingtaine d'années.

Ce premier volume sur les Poissons de la Faune Ibérique est consacré à une introduction générale où l'auteur donne, avec le développement nécessaire et suffisant, les éléments de morphologie extérieure et intérieure des poissons indispensables pour l'étude de l'ichthyologie systématique, aussi bien que quelques notions d'ordre biologique, telles que celles ayant trait au milieu où ces animaux vivent, leur développement, alimentation, etc. Dans un second chapitre de l'introduction le lecteur trouve beaucoup de renseignements utiles sur les moyens et les méthodes employées dans les recherches ichthyologiques, comme l'aménagement d'aquariums, engins de pêche, conservation des spécimens, etc. Cette première partie, bien illustrée, forme à elle seule un tiers du volume (236 pp.).

La deuxième partie commence par un court chapitre sur la faune ibérique en général, sur les normes adoptées dans l'exposition et sur la classification (pp. 237– 251); après cela viens la description des espèces, le chapitre II étant consacré aux Cyclostomes, très peu nombreux d'ailleurs, et le III aux Élasmobranches. Celui-ci occupe plus de la moitié du volume (pp. 273—668), ce qui ne doit pas nous étonner dès qu'on remarque que soixante-douze espèces de cette sous-classe ont été trouvées autour de l'Espagne et du Portugal. Chaque espèce est décrite avec beaucoup de détails et représentée soit par des figures dans le texte, au nombre de 125, soit dans les vingt belles planches en héliotypie dues au talent d'un peintre malheureusement décédé, Santiago Simon.

Le Prof. Lozano, dont les recherches antérieures sur les Poissons ibériques et du Maroc Espagnol l'avaient préparé pour cette tâche, donne aussi, pour chaque espèce, les noms vulgaires non seulement dans les diverses régions de l'Espagne mais aussi au Portugal. Il cite aussi quelques uns des synonimes scientifiques. C'est dommage qu'il ne donne pas la liste de ces synonimes aussi complète que possible, au moins de ceux qui ont été employés par les divers auteurs qui se sont occupés spécialement de la faune de la Péninsule. Il a préféré aussi metre la bibliographie à la fin de l'ouvrage complète, mais ce serait bien utile aux chercheurs de l'avoir aussi pour chaque espèce. Nous savons bien que celà surchargerait trop le texte, mais l'avantage n'en serait pas moindre, surtout pour une région dont la bibliographie est, d'une façon générale, peu connue. Il serait tout-à-fait désirable d'avoir, pour la Péninsule Ibérique dans sons ensemble, une sorte de catalogue organisé dans le genre de celui que, pour les côtes méditérranéennes de l'Espagne et du Maroc et pour les côtes ibériques et africaines du Golfe de Gibraltar a été publié, il y a peu d'années, par un

autre infatigable ichthyologiste espagnol, M. Fernando de Buen, ou à celui, publié en 1911, pour le Portugal, par M. A. F. de Seabra.

Ce premier volume se termine par un bon index des noms scientifiques et vulgaires des espèces décrites.

Le livre du Prof. Lozano, nous le croyons bien, est un ouvrage qui marque un progrès considérable non seulement dans l'Ichthyologie espagnole mais aussi de l'Ibérie entière. A. Ramalho.

H. Henking. Die Ostseefischerei. Handbuch der Seefischerei Nordeuropas. Bd. V, Heft 3. pp. 182. 1 Map, 29 Plates and 156 Figures. Stuttgart, 1929.

This part of the large "Sea Fisheries Handbook" is a work really remarkable in several respects. It is primarily a study of the sea fishery on the Baltic coast of Germany, but the fisheries in adjacent countries (Poland and Denmark) are also touched upon. The book is written by a specialist who, having worked on the Baltic coast for many years, is intimately acquainted with this part of his country, and whose work has been instrumental in promoting the development of the German fishery in the Baltic. Professor Henking has given in this study not only a careful description of an overwhelming quantity of facts about the fishery, but has also added many details known only from his personal experience. The whole book is characterised by the personality of the author, who, well-known as "Altmeister der See-Fischerei", is here dealing with his favourite subject, to which he has devoted some forty years of his life.

In this book the fishery in the Baltic is treated mainly with regard to its historical development, with special attention to the developments of the last decade. The author also gives a fair statement of the present condition of the fishery, which permits his reader to estimate the possibilities for future development.

The work is divided into seven principal chapters, with many subdivisions. In the Introduction, the author draws a brief comparison between the Mediterranean and Baltic Seas; he points to the main differences not only between the physiographical characters of the seas, but also between the conditions of the fisheries and the methods used in the two regions. The yearly migration of some million people to and from the bathing resorts on the coast, as well as the significance for the fishery of geological changes in northern Europe are referred to.

The first chapter is devoted to the earliest history of the Baltic fishery, beginning with the somewhat vague accounts of the migrations of the various peoples to and from the coast. The author points out (in accordance with Schäffer) that, in historical times up to the 12th century, the southern coast of the Baltic was inhabited by Slavs, and it was not until after this time that the expansion of the German race, and of the German fishery and trade also, proceeded with ever increasing energy. The reconstruction of the old towns, occupied and provided with fresh legislation by the Germans, and the formation of the well-known "Hanseatic League" greatly assisted the development of the fishery in the Baltic. The principal

place at which the fishery achieved an importance never reached in later centuries was the small peninsula of Schonen, where the two small towns, Falsterbo and Skanor, were situated. In a special chapter, the author gives a vivid description of the important herring fishery in the neighbourhood of Schonen, and compares the catches with the results of recent fishing in the Baltic. It seems to him that in those early times, with very primitive methods and a limited population, the total results of the fishery were not very different from the best results in recent times.

The next part of the book is a systematic description of the fishery in all parts of the coast, from Denmark to the Polish frontier and onwards from the Free Town of Danzig to East Prussia.

The centres of the most important fisheries are described and discussed in great detail. It goes without saying, however, that, in a short abstract such as this, it is impossible to refer to all the interesting information given in this chapter: the author sometimes merely glances at some far-reaching problem of the fishery, or he may give a short account of the results of experiments and observations made over many years.

The author chiefly associates the rapid development of the fishery in the north-western part of the Baltic, near the Danish frontier, with the introduction of very large numbers of motor-boats and also with the increase of population due to the immigration of fishermen from the eastern parts of the coast. According to the author's description, it seems that this part of the Baltic coast played a very important rôle in the development of the German fishery. A peculiar method of fishing for sprats and herrings with large fixed nets was tried for the first time near Eckernförde; the Danish "Ringwade" was also introduced in this district, and the immigrants from the eastern part of the Baltic brought with them the use of small trawls (Zeese). But the most important step in the development of the fishery was the introduction of motor-boats and of larger vessels provided with reservoirs for living fish (Bünn); both these innovations were adopted from the Danish fishermen. The employment of motors in fishing vessels caused a sort of revolution in the Baltic fishery, and their use has been promoted since 1908 not only by the German Sea Fisheries Society but also by the German motor industry. The author points out that the fishermen who were without motor-boats were unable to take a sufficient quantity of fish on the nearer grounds, already overfished by the motor-boats, and they were also always too late at the markets. In consequence of this, the necessity arose to seek the fish farther from the shore; this brought about the construction of larger vessels, but it was also associated with a gradual decrease in the quantity of fish in the Baltic. The author expresses the opinion that the quantity of plaice is rapidly diminishing, and that the females especially have become very rare in recent years. The latter opinion is based upon the statistics of the quantities of males and females caught in fixed nets 1000 m. long; but this very difficult question of change in the proportions of the sexes in the plaice is not confirmed by the author by other investigations.

Other districts of the German coast are successively described in the same way as the western part of the Baltic.

The sprat fishery in the neighbourhood of Nierendorf, the pollution

of the river Trave, the herring fishery near Wismar and Wustrow, and many other features are very carefully described. This part of the book can be regarded as a sort of encyclopaedia in which all the characteristic features of the fishery in each locality of the coast are collected. To this description reports of the fishery in every large district during the years 1926 and 1927 are appended. Special attention is paid to the conditions of the fish trade in the larger ports, e.g. Stralsund and Stettin. One of the most interesting chapters of the book describes the fishery on the Island of Rügen, where Slav settlements were situated in ancient times, and where the main fishing season in the last century was opened with special religious services. Here motor-boats are very seldom used, and the canning industry has replaced the curing of herrings.

The conditions of the fishery in the eastern part of the German coast are similarly described, with special attention to the fishery near the mouth of the river Oder and near the small town of Leba. From this port, however, about 50 large motor-cutters (the largest of that kind of vessel used in the Baltic) are engaged in fishing. The description of the fishery in East Prussia and in the Haffs, which includes some interesting comments on the special industry of the manufacture of fish oil from Sticklebacks, forms the last chapter of the systematic review of the sea fisheries at every locality along the German coast.

The third part of the book deals with the development of the fishing vessels in the Baltic. Every type of vessel, illustrated by fine photographs or drawings, is fully described, and its good or bad qualities indicated. Of special interest is the author's statement that the vessels now used, in particular the motor-boats, are mainly modelled on those used in Sweden or Denmark, especially in the Island of Bornholm.

In the next part the author discusses the various kinds of fishing gear not fully dealt with in the systematic review of the fishery in the different localities. The description of the fishermens organisations and of the insurance companies forms an interesting chapter in this section. A short chapter deals with the use of "marks" on the fishing gear; the illustrations in this chapter are photographs of the fishing gear used in the Polish port Hel.

The chief species of fish in the Baltic are briefly described, and the history of the fishery and the present state of the stock of fish is remarked upon. The statistical data, based chiefly upon the figures from 1924 and 1925, are also discussed.

Comments on the fisheries for mussels, seals, and other marine animals are to be found in the last chapter.

Professor HENKING's book, with its wealth of detail, vivid descriptions, and the historical and ethnographical information contained in it, must interest everyone who wishes to understand the economic conditions and to estimate the possibilities for development of the fishing and other industries on the Baltic coast of Germany. The illustrations and photographs deserve special mention; many of them are really artistic, and the diagrammatic illustrations of the methods of fishing are clear and instructive. The book as a whole indubitably forms one of the most interesting parts of the "Sea Fisheries Handbook". M. SIEDLECKI.

(1) R. Kändler. Untersuchungen über die Biologie der Auster. No. 3. Verbreitung und Wachstum der Austernbrut im Wattenmeer. Wissenschaftliche Meeresuntersuchungen. Band XVII, Nr. 3. Oldenburg i. O. 1928.

(2) Herbert F. Prytherch. Investigation of the Physical Conditions Controlling Spawning of Oysters and the Occurrence, Distribution, and Setting of Oyster Larvae in Milford Harbor, Connecticut. Bulletin of the Bureau of Fisheries, Vol. XLIV, 1928. (Document No. 1054). Washington, 1929.

Why young oysters in the planktonic stage are not all dispersed by tidal currents till they are far from the locality where they were spawned has always evoked great interest, particularly where more or less isolated beds are concerned. The discoveries made by Julius Nelson about 1908 with *Ostrea virginica*, and by Hagmeier in 1912 with *O. edulis*, that this stage may last for a fortnight or more, and not merely for a day or two as was at one time believed, further accentuated the problem. Both the present investigations bear directly on this question, although the conclusions reached are not in agreement.

(1) Dr. Kändler's work was carried out in the summers of 1926 and 1927 in the shallow water on the East side of Sylt, on the West coast of Schleswig-Holstein, where, with a view to restoration of the oyster fishery, a large number of Dutch oysters had been laid. It was desired to ascertain not only if these oysters would produce larvae capable of developing to the size of readiness for setting, but also their numbers and distribution in the "Wattenmeer", and the conditions requisite for an adequate fall of spat. Hydrographical observations and a large number of hauls with a fine mesh townet were made at various stations throughout the area during July and August each year. The number and size of the larvae caught were determined. They were attributed to the Dutch spawners because the number of native oysters remaining was altogether insignificant. Spawning occurred somewhat later in 1927 than in 1926. Large numbers of larvae were caught, and as each season progressed, all sizes up to that immediately preceding the setting stage were found in the catches, the largest forming up to 5 % of the catch in 1926, and 10 % in 1927. The distribution of the larvae could be traced from the laying on the Ellenbogen Bank, first along the East coast of Sylt with the flood, then back into the List channel with the ebb, and ultimately to the innermost portions of the shallows, where the fully developed larvae reached their highest proportions. According to Hagmeier's conclusions, larvae take ten to fourteen days to reach setting size at a water temperature of 18 – 21° C., and the presence of well advanced larvae in the inner portions of the "Wattenmeer" is very significant.

The author gives topographical detail and hydrographical records, together with the data of the larvae taken. He discusses spawning, the development and growth of oyster larvae in relation to water temperature and tidal currents, and the setting of spat. The two seasons concerned proved unsuccessful for the collection of spat, and it is not possible therefore to draw any conclusions regarding the adequacy of the spawn produced

by the Dutch stock oysters, particularly as no similar records of catches of larvae are available for comparison. There was no marked difference between the numbers of larvae caught on the flood and the ebb tides.

Dr. KÄNDLER attributes the presence of advanced larvae in the inner shallows to the action of favourable tidal currents alone, thus differing from JULIUS and THURLOW NELSON. They found a similar abundance of advanced larvae of *O. virginica* at the head of tidal inlets in spite of a resultant seaward drift, but they noticed differences in the vertical distribution of larvae according to the stage of their development. The more advanced larvae were abundant near the surface on the flood tide, but not on the ebb; early larvae being evenly distributed, considerable numbers of them were carried out to open water and were thus lost. This led to the conclusion that the older larvae exhibit an interesting adaptation, whereby they are able to remain close to or on the bottom during the ebb, but rise on the flood, and so are carried inshore by the incoming tide. As Dr. KÄNDLER points out, however, this postulates a somewhat remarkable faculty in the larvae for distinguishing between ebb and flood. Yet another explanation is put forward by Mr. PRYTHERCH, whose observations discussed below differ in certain important respects from those just referred to above.

(2) The work described by Mr. PRYTHERCH was undertaken in 1925 and continued in 1926 and 1927, chiefly to ascertain the causes underlying the annual variations in the production of seed oysters which are so marked both on natural and on cultivated beds. Milford Harbor, a small inlet on the North side of Long Island Sound was selected for this research. With about half of its area exposed at low water, it forms a typical oyster producing creek of this region, but having been fished out, it had to be restocked before the research could begin. Hydrographical observations were made at six stations on a line passing from well inside the creek out into the Sound. The apparatus used included a long distance thermograph, an automatic tide gauge, current meters and drift bottles. Plankton samples were also taken at these stations, consisting of fifty gallons of water pumped from near the bottom and the surface to ascertain the quantity and distribution of the larvae. At certain periods other samples were taken hourly. Setting of larvae was studied by the examination of specially distributed collectors. Samples of the bottom were also examined, but details of the method of sampling are not included in the present paper. The Weather Bureau of an adjacent locality furnished climatological data, whence variations from normal conditions for the time of year were ascertained for each month of the investigations.

The author found that during the seasons under investigation, annual variations in production were correlated with water temperatures. Successful years were those when air and water were above normal. With temperatures below normal the set of spat practically failed. Maturation and spawning were affected by temperatures earlier and later in the summer respectively. Spawning was dependent on an increase in water temperature to 20° C., this figure being reached usually in July or early in August at the time of the full moon spring tides, when the area of tidal flats ex-

posed to the heating action of the sun was at a maximum. It is interesting to note in passing that Orton found a similar correlation in *O. edulis*, but in this species spawning begins at a lower temperature, namely about 15° C.

The results of most striking interest are those concerning the distribution of larvae during the tidal period. Larvae were found most abundantly at low slack water. As soon as the current velocity increased to about 0.5 ft. per second (about 9 metres per minute), larvae practically disappeared from the water, but could be found on the bottom. This behaviour of larvae was confirmed by experiments made in a small tank. The larval period averaged fifteen days at a mean temperature of 21.5° C., during which the larvae remained on the bottom except when horizontal movement of the water was at a minimum. It is thus that the author explains how the area of setting came to be found with its greatest intensity within three hundred yards of the centre of the spawning bed in the creek. From his evidence he rejects the derivation of this spat from larvae carried into the creek from the Sound. Furthermore, he found a definite correlation between current velocity and the time of actual setting of the spat. It occurred during low slack water and continued till the flood tide reached a velocity of twenty feet (ca. six metres) per minute. As regards vertical distribution, setting was most intense round about mean low water line, though it ranged from the channel bottom to two feet above low water line. Thus, according to this author's conclusions, larvae are affected by the velocity but not the direction of tidal currents.

Mr. Prytherch has also devoted attention to the problem of prediction of spawning and setting of spat, whereby the placing of cultch can be arranged to obtain the best production of spat. It may be mentioned here that the idea is not new. Julius Nelson in 1912 drew attention in the following words to its feasibility:— "It cannot be too strongly urged as a general thing that in our Northern waters oysters spawn at a definite date, which can be foretold sufficiently early to allow of planting suitable cultch to catch the spat under the best conditions". Thus Thurlow Nelson in 1916, for example, was able to post up an accurate prediction of the date of setting a week ahead of its beginning. Mr. Prytherch has sought to extend the scope of such predictions, not only as regards time but locality and intensity of setting, and he includes in this paper a detailed consideration of the basis on which he has undertaken predictions as much as one month ahead. He is to be congratulated on the accuracy of his prediction for 1928, — an outcome of the present research. It is interesting to note from a recent "Fisheries Service Bulletin" that the practice of issuing predictions was discontinued last year (1929), and supplanted by conferences at the Milford laboratory with representatives from all the large oyster growing concerns in the locality.

In comparing the conclusions regarding distribution of larvae reached by the investigators mentioned above, it should be borne in mind that there were considerable differences in the object, scope, and methods of each, in addition to the great differences of local conditions, and some factors may have been overlooked. For instance, J. Nelson concluded

in 1915 that the movements of larvae are influenced not only by temperature, warm weather causing the fry to rise, while cold weather drives them down; but also that they tend to stay near the bottom at night, while they rise when daylight appears. T. Nelson drew attention also to the irregular horizontal distribution of larvae; their occurrence in large numbers in what he calls "slicks", with practically none in the adjacent water. The result noted by Mr. Prytherch during his current experiment with larvae in a tank certainly seems definite enough, and suggests interesting results from similar tests with *O. edulis*, and with different stages of *O. virginica* larvae. A similar research by him in a second locality should yield valuable information on the relative importance of tidal currents and other factors, and the reaction of larvae to them. H. P. S.

Fishery Board for Scotland. Crab Marking Experiments. Fisheries, Scotland, Sci. Invest., 1928, IV. Edinburgh, 1929.

The results of the crab marking experiments which were carried out during the years, 1916—1924, under the direction of Dr. H. C. Williamson have been published by the Fishery Board for Scotland. Full particulars are given in two tables, the first of which indicates the date and place of marking and the condition of the crabs, and the second the data relating to the recaptures. Charts are added to illustrate the more outstanding records. The results are published without comment but as they are of economic and scientific importance the attempt may be made to draw attention to some of them.

From the first table it may be seen that the proportion recaptured was small, only 7 per cent. In one or two cases the numbers returned rose to 14 or even 20 per cent. We had the same experience with reference to some of our experiments on the Northumberland coast. But when we made our last series of experiments we obtained a return of 27 per cent., and there is little doubt that such a favourable result was owing to a gain in experience of handling and marking.

The seasonal migrations, outwards in winter and inwards in summer, have long been known and are illustrated in the results of the Scottish experiments. More important is the abundant confirmation of the migration of the females to the north on the approach of maturity. An indication of this up-current migration of the females was found in the earlier experiments of Williamson made as far back as 1897—98 at Dunbar. A female marked in September was recaptured at St. Andrews in April. The Northumberland experiments began about the same time and, year after year, showed that such a migration was universally the fact with regard to the females about to become berried. This was confirmed by experiments which were made on the coast of Yorkshire. The present experiments show that the like is true for the east coast of Scotland. This succession of results points to a migratory habit affecting the crab population of the east coast of Britain, north of the Wash, and it is more than probable that the habit is not confined to the crabs of that region.

Of the crabs which migrated from the place of marking the average distance of migration northwards of the females was 52 miles and of the

males (three examples only) 31 miles. The average migration southwards of the females was 12 miles and of the males 8 miles. It is an interesting feature of the results that the migrants to the north were nearly always females marked in October, and this was the case also with reference to examples captured in years subsequent to that of marking.

The results therefore are of great interest, and it is to be hoped that similar experiments will be made elsewhere. They confirm previous experiments. The only exception is that in three cases a northerly migration of the male was found to take place. Even so, the small number involved in an experiment which concerned nearly 3000 specimens indicates that the occurrence is sporadic and it is unessential. It is evident also that there is no return migration. ALEXANDER MEEK.

B. HAVINGA. Krebse und Weichtiere. Handbuch der Seefischerei Nordeuropas. Bd. III, H. 2, pp. 147. Stuttgart, 1929.

This paper deals with the systematic position, structure, physiology, habits and life history of the economically important Crustacea and Mollusca of northern Europe. The animals dealt with consist of the lobster (*Homarus*), Norway lobster (*Nephrops*), rock lobster (*Palinurus*), the edible and shore crabs (*Cancer* and *Carcinus*), shrimp (*Crangon*), the prawns (*Pandalus* and *Leander*), the mussel (*Mytilus*), cockle (*Cardium*), clam (*Mya*), oysters (*Ostrea* and *Gryphea*), scallops (*Pecten*), whelk (*Buccinum*) and periwinkle (*Littorina*). It is essentially a compilation and not an original work and is therefore difficult to review.

The value of such a compilation is, however, considerable. It brings together into a compact and readable form much scattered information. After a general account of the group — *Decapoda*, *Lamellibranchia* or *Gastropoda* — in question, the author goes on to discuss each animal separately and leads on logically from structure to function then to the mode of life, reproduction, growth and so finally to the economic value. Interesting data on aquiculture, e.g. lobster hatching and oyster culture, are given, though some illustrations of the latter process might with advantage have been given.

The growing tendency in such works as the one under review to associate function with structure is to be noted with satisfaction as a triumph for common sense (also, of course, as an indication of the gradual development of this hitherto greatly neglected branch of knowledge). In the present case, however, the information given is somewhat sketchy and it is doubtful whether any very clear idea would be conveyed to any reader previously ignorant of the subject.

The paper is well produced, the illustrations (with the exception of the omission noted above) excellently chosen and clearly reproduced. The author has avoided with commendable originality the old, time-honoured illustrations and taken the majority from recent papers, while his own photographs are exceptionally clear. There are extensive bibliographies which have the great advantage of omitting the old work which has no longer any but an historical interest and is clearly out of place in what is essentially a practical work. C. M. YONGE.

Current Bibliography.

Prepared by the Editor with the assistance of Miss THURSBY-PELHAM.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. ALLEN's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted.

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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